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ABSTRACT

Four general product classes (pesticides, paint products, household cleaners, and automotive products) are reviewed in this document. Each product class is described, and several aspects of the problem associated with product use or disposal are examined, including estimates of volumes used and environmental impacts. Technical data on the specific chemicals which are most often found in these products are provided. This information (which includes sources, consumption figures, toxicity ratings, human health hazards, physical characteristics, environmental effects, and disposal recommendations) is presented in lengthy tables at the end of each product section. The appendices provide a simplified overview of organic chemistry as it applies to consumer products, and a discussion of toxicity and hazard (including measurements of and differences between the two terms). Pesticides solvents and motor oil were "red-flagged" as being of special interest in that they all have the potential to harm the environment, they are used in significant quantities, and they may be disposed of in harmful ways. (JN)

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TOXICANTS IN CONSUMER PRODUCTS

Household Hazardous Waste Disposal Project

Metro Toxicant Program
Report No. 1B

Water Quality Division
August 1982

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TOXICANTS IN CONSUMER PRODUCTS

REPORT B

OF THE

HOUSEHOLD HAZARDOUS WASTE DISPOSAL PROJECT
METRO TOXICANT PROGRAM #1

by

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EPA Grant No. P-000233-01

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DISCLAIMER

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FOREWORD AND ACKNOWLEDGEMENTS

HOUSEHOLD HAZARDOUS WASTE -- WHAT'S IT ALL ABOUT? To most people, hazardous wastes are found only in Love Canal, in large industrial dumps or in streams of toxic chemicals flowing from factory outfalls. But hazardous waste is really any substance that, when disposed of, poses a risk (e.g., ignitable, toxic) to people or to the environment.

A wide range of household products fits such a definition: pesticides, automotive oil, solvents, household cleaners, antifreeze, and others. Some of the chemicals found in these products are known or suspected mutagens, carcinogens or teratogens. Often they are toxic to human beings, fish, and wildlife in small amounts. Every day, literally tons of these chemicals are washed down drains or dumped in the trash. Because they come from many small, diverse sources (households) rather than a few large, localized sources (industries), they are difficult to control and are not currently regulated.

In addition, sales of a number of household toxic substances -- including certain pesticides and vinyl chloride-containing products -- have been banned or severely restricted. Quantities of these banned products can still be found in people's homes. The average consumer has had no choice, until now, but to dispose of these toxic products in ways allowing their eventual release into the environment.

WHY IS METRO CONCERNED ABOUT HOUSEHOLD HAZARDOUS WASTE? As the regional agency responsible for water quality and sewage treatment -- as well as transit service -- in King County, Metro is interested in keeping the region's waters clean. Metro has initiated a Toxicant Pretreatment Planning Study, a Toxicant Inventory Study and other related projects as part of its commitment to assess the presence, sources, fates and effects of toxic substances in the local waters. The studies will help Metro identify problems and formulate effective control programs for point and nonpoint sources of problem toxicants.

HOUSEHOLDS CONTRIBUTE SIGNIFICANTLY to wastewater flows to the sewage treatment plants and solid waste to landfills. House, garden and garage products, such as paints, preservatives, pesticides, antifreeze, and oil can contaminate local stormwater runoff and streams. While not large when compared to industrial contributions, household hazardous wastes can be a source of problem toxicants in local waters.

BECAUSE OF THESE CONCERNS, METRO HAS BEEN STUDYING this issue and its implications as part of its Toxicant Control Program. In 1981 Metro received a water quality management grant from the

U.S. Environmental Protection Agency to develop a disposal plan for small quantities of household toxicants. The Household Hazardous Waste Disposal (HHWD) Project was established as an interagency effort, coordinated by Metro and based on a working committee representing governmental agencies, private business, environmental and public interest groups, and concerned citizens. The goal of the project was to reduce the level of toxicants entering the environment by providing a solution to the problem of unsafe or improper disposal of household hazardous wastes.

THIS EXAMINATION OF THE TOXIC SUBSTANCES IN CONSUMER PRODUCTS is one part of the final report of the Household Hazardous Waste Disposal Project, which includes the following components (separately bound):

A. Summary,
B. Toxicants in Consumer Products,
C. Public Opinions and Actions,
D. SLEUTH -- Educational Activities, and
E. Directory.

THIS REPORT CONSTITUTES OUR SECOND PUBLICATION on consumer products and their toxic contents. The first was an interim report, entitled the Technical Memorandum, which was produced primarily to provide a working document for the HHWD Committee to use in its decision-making functions, as well as a first draft to this report. It was used as background information during the project as we explored disposal options in the Seattle area for these different product classes, tested some of those options in the pilot project and decided on a final control plan for household quantities of toxicants for this region. Details of this process and its result can be found in Part A, the Summary report.

MUCH OF THE INFORMATION in this report, Toxicants in Consumer Products, is taken directly from the Technical Memorandum. Much of the research for the latter document was conducted by HHWD Committee Members, and we would like to sincerely thank the following members and their organizations for the time, thought and effort that they put into researching and writing their sections (*denotes major authors):

Automotive Products

*Patt O'Flaherty - formerly City of Bellevue
Julie Sellick - Department of Ecology
Chris Chapman - Washington Citizens for Recycling

Pesticides

*Chris Luboff - Western Washington Toxics Coalition
*Bob Freimark - formerly King County Cooperative Extension Service

Pesticides (continued)

Greg Bishop - Seattle/King County Health Department
Pam Crocker-Davis - Seattle Audubon Society/Washington Environmental Council

Paint Products

*Judy Fey - U.S. Environmental Protection Agency
Ray Carveth - Metro Industrial Waste Section

Household Cleaners

*Sue Mason - Citizens Water Quality Advisory Committee
*Sue Synder
Steve Bobbink - Poison Control Center

THE TECHNICAL MEMORANDUM was our first cut at gathering this information together, but there were still many gaps. The report was sent out to a great many people in an attempt to receive some critical review and, hopefully, fill in these gaps. The following people made a special effort to review and comment on our document, and we thank them. We have tried whenever feasible to incorporate their comments into the present report.

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Robert Nelson - National Paint and Coatings Association
Eleanor Price - Washington State Senate Energy and Utilities Committee
James Rogers - South East Michigan Council of Governments
Michael Watson, Ph.D. - U.S. Environmental Protection Agency, Region X

Joe Simmler, Supervisor of the Toxicant Program at Metro, provided technical input as well as invaluable support throughout the project.

GIVEN THE EXTENT OF INTEREST that was shown in the Technical Memorandum both by the general public and by specialists in the field, we hope that this report will be found interesting and useful by a great number of people. We have assembled as much information as possible about toxic consumer products in this volume in order to provide in one place all of the details available on this subject. If you would like more information on the subject, access to the other reports, or information on related activities, please contact Metro at (206) 447-5885. Your comments are most welcome.

David V. Galvin
Project Manager, Metro

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Project Coordinator
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ABSTRACT

Four general product classes -- pesticides, paint products, household cleaners and automotive products -- are reviewed in this document. Each product class is described, and several aspects of the problem associated with product use or disposal are examined, including estimates of volumes used and environmental impacts. Technical data on the specific chemicals which are most often found in these products are provided. This information, which includes sources, consumption figures, toxicity ratings, human health hazards, physical characteristics, environmental effects and disposal recommendations, is presented in lengthy tables at the end of each product section. The Appendices provide a simplified overview of organic chemistry as it applies to consumer products, and a discussion of toxicity and hazard -- measurements of and differences between the two terms.

Each class of products tends to have its particular areas of concern, such as labeling deficiencies, toxicity or persistence of the contents, disposal route, volumes used, etc. Three kinds of products were "red-flagged" as being of special interest in that they all have the potential to harm the environment, they are used in significant quantities, and they may be disposed of in harmful ways. These are:

- Pesticides;
- Solvents, especially the chlorinated organics; and
- Motor oil.

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SECTION I

INTRODUCTION

This report, Toxicants in Consumer Products, is an attempt to answer the question, "What products found in the home may be toxic, and do they have any effect on the environment through their disposal?" There are several stages necessary in answering this question.

First we need to determine what constitutes toxicity in a product. Appendix B provides an explanation of this concept, and of what we mean when we use the terms "toxic" or "hazardous."

The second stage involves selecting those consumer products to examine and determine their toxicity and potential for environmental harm. Faced with the vast array of consumer products which contain toxicants and/or could be considered hazardous, we have made the decision to concentrate on only four classes of products that we consider of greatest concern. These are (1) automotive products, (2) pesticides, (3) paints, solvents and preservatives, and (4) household cleaners. We have not attempted to cover any hazards which fall under the following categories, yet which still could technically be considered "household hazardous waste:"

cosmetics,
medicines and ointments,
building materials (e.g., urea formaldehyde),
clothing,
emissions from heating and cooling devices,
garbage and solid waste,
hobby chemicals,
plastics and plasticizers,
photographic chemicals,
radiation,
tobacco smoke,
utensil coatings,
toxins in vegetation,
special ornaments, or

any toxic wastes from small businesses or commercial enterprises, even if such operations are based in a home (painting contractors, for example). We frankly admit that the decision of what to review and what not to review was somewhat arbitrary. For instance, the decision to exclude cosmetics meant that all the shampoos, hair dyes, deodorants, and so on which may be toxic and often end up in the environment had to be ignored. For information on hazards of cosmetics, interested readers are referred to Conry (1980).

Likewise, hobby or art chemicals may be the most dangerous materials that the homeowner comes in contact with, under certain circumstances; a thorough examination of these substances is found in McCann (1979).

Those classes of products that were chosen to be reviewed were selected because we perceived that they were commonly used in large volumes in the home, and which also had the greatest potential for environmental contamination. For instance, urea formaldehyde as an insulation material has been commonly used in fairly large volumes, but is not, in most cases, disposed of in a manner which would be likely to pollute the environment. Many of these other household materials that could be considered toxic or hazardous are discussed in Fritsch (1978).

For the different product classes (pesticides, paint products, household cleaners and automotive products), different methods were used to obtain the chemicals found in these products. An explanation of the study methodology for each product class can be found in the pertinent chapter. Once these chemicals were determined, however, the actual research process was fairly standard. The information was compiled from reputable sources, such as OSHA standards, toxicology references, and other reliable texts. Every attempt was made to use standardized information (for instance, water quality criteria, or standards for inhalation exposure) which could be compared between chemicals. This method unfortunately often results in an "alphabet soup" of letters and numbers; technical terms, abbreviations and unfamiliar concepts were all carefully cross-referenced to Appendix C. Furthermore, every entry has been referenced with a source citation number to facilitate tracking down information within each product class.

Although our primary interest was in the environmental aspects of these toxicants, for many of these chemicals the majority of information available is for human health effects or for effects on test animals. We caution that these should not be used to draw any inferences about the chemical's effect in the natural environment. Furthermore, even their applicability to the home situation is uncertain. Chemical standards for the workplace are based on a 40-hour work week at fairly high concentrations. On the average, only 20 percent of a worker's overall time is spent on the job, while 60-85 percent is spent at home (Conry, 1982). Toxicants in the home will tend to expose people over a longer period of time, at a lower concentration. Furthermore, workplace standards are based on healthy adults -- children and the infirm are much more sensitive to such pollutants (Conry, 1982).

Most standards for each individual chemical were developed in isolation from other substances. Consumer products, however, are a mixture of chemicals. The individual chemical under review may only comprise some small percentage of the total volume of the product. The other ingredients in the product may dilute the effect, or may react synergistically with the chemical to boost the effect. The ramifications from these and other possibilities present so many unknowns that a true assessment of what is hazardous becomes extremely difficult.

These same kinds of problems are magnified when attempting to gauge the effect of these chemicals in the environment. The majority of research that has been done has been on the chemical alone, not in mixtures. If available at all, aquatic toxicity ratings refer to levels of acute toxicity. This is pertinent for those situations where the homeowner directly discharges a "slug" of some product into the ground or stream (for instance, dumping a quart of oil down the storm drain), but not for the long-term, chronic effects of other use patterns (for instance, slow leakage of phenolic compounds from a failing septic tank). Specific problems in this regard have been examined in the relevant product chapters.

Keeping all of these caveats in mind, the reader should find a wealth of information in these pages. The four general product classes -- pesticides, paint products, household cleaners and automotive products -- are reviewed. Background information, usage figures and environmental impacts are presented. Technical data, such as sources, toxicities, and health hazards on specific chemicals of concern are compiled in lengthy tables at the end of each product class section. Appendices include a simplified overview of organic chemistry, a discussion of toxicity and hazard, measurements of and differences between the two terms, and such useful attachments as a glossary, list of abbreviations, and cross-referenced index to chemicals mentioned in the text.

SECTION II

PESTICIDES

A. BACKGROUND INFORMATION

1. Definitions

A pesticide, according to federal law, is "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating" insects, rodents, fungi, weeds, and other forms of plant and animal life which are "injurious to health or the environment." "Other forms" include bacteria and viruses, except within man and animals (poisons that affect internal pests are called "drugs").

When we refer to pesticides, therefore, we refer not only to that class of home and garden chemicals such as insect sprays and weed killers which are commonly called pesticides, but also to disinfectants and wood preservatives which contain substances that will kill or repel living organisms. In this document, we have chosen to deal with disinfectants in the Household Cleaners section (page 103), and with wood preservatives in the Paint Products section (page 51). This was done because most people associate these products with those categories, but it should be remembered that such products are pesticides and they should be handled accordingly.

Pesticides are broadly classified according to the "target organism" -- insecticides kill insects; herbicides kill plants; rodenticides kill rodents (such as rats); molluscicides kill mollusks (such as slugs); and fungicides kill molds and other fungi. There are also pest repellants, such as mosquito "dope," designed to merely repel insects rather than kill them. Synergists or activators are chemicals which may be added to a pesticide formulation to make it more effective. Within these broad classifications, pesticides may be further broken down according to their chemical class.

Table 1 outlines some classes of pesticide chemicals found in consumer products, with examples of specifications in each class.

2. Regulatory Framework

The Federal Insecticide, Fungicide, and Rodenticide Act (PL 92-615/95-396, 7 USC 136) -- commonly called "FIFRA" -- regulates the manufacture, use, and disposal of "economic poisons" for agricultural, forestry, household, and other activities. It requires registration of all pesticides, classifies pesticides

Table 1. PESTICIDE CLASSES AND EXAMPLES FOUND IN HOUSEHOLD PRODUCTS.

INSECTICIDES

A. Organophosphates
- Acephate
- Chlorpyrifos
- Diazinon®
- Dichlorvos
- Disulfoton
- Malathion
- Methyl-demeton
- Naled
- Ronnel
- Stirofos
- Trichlorfon

B. Carbamates
- Carbaryl (e.g., Sevin®)
- Maneb
- Propoxur (e.g., Baygon®)

C. Organochlorines
- Chlordane*
- DDT*
- Lindane (e.g., Kwell®)
- Methoxychlor

D. Organosulphurs
- Ovex

E. Botanicals/Microbials/Synergists
- _Bacillus thuringiensis_
- Piperonyl butoxide
- Pyrethrin
- Rotenone

HERBICIDES

A. Arsenicals
- Arsenic trioxide/Cacodylic acid

B. Chlorophenoxy acids
- 2,4-D
- 2,4,5-T*

C. Triazines
- Prometone

---

*No longer found in consumer products, but may still be in households in old products.

Table 1. PESTICIDE CLASSES AND EXAMPLES FOUND IN HOUSEHOLD PRODUCTS (Continued)

D. Benzoic Acid Derivatives
  - Dicamba
  - Dichlobenil

E. Phenol Derivatives
  - Pentachlorophenol

F. Glycene Derivatives
  - Glyphosate (e.g., Roundup®)

G. Ureas
  - Divron

FUNGICIDES

A. Dicarboximides
  - Captan
  - Folpet

B. Benzimidazoles
  - Benomyl

C. Triazines
  - Anilazine

RODENTICIDES

A. Coumarins
  - Fumarin®
  - Warfarin (e.g., D-Con®)

MULLUSCICIDES

A. Aliphatic Hydrocarbons
  - Metaldehyde (e.g., Slug-Bait®)

---

or general (e.g., household) versus restricted use, requires "informative and accurate labeling," and provides for suspension or cancellation of registrations for "imminent hazard" or "unreasonable adverse effects on the environment."

a. Registration of Pesticides. A pesticide must be registered by EPA to be sold. All pesticides on the market at the enactment of FIFRA in 1972 were given a blanket ("grandfather") registration. Review of these thousands of chemicals is a slow process. It is important to recognize, therefore, that EPA registration of a pesticide does not necessarily mean that it has been tested for safety. Only about 40 substances have had registration cancelled or registered uses suspended. Table 2 provides a list of these suspended or cancelled pesticides.

A number of other pesticides are under formal review for possible de-registration at this time because of some significant questions about their hazard to health or the environment. The review process is called "RPAR:" Rebuttable Presumption Against Registration. Whenever certain risk criteria established by EPA are exceeded in any studies of a pesticide, EPA will "issue an RPAR" which triggers an in-depth scientific review of the substance in question. If the presumption of risk can be rebutted or the benefits are shown to outweigh the risks, registration may be granted or continued (U.S. EPA, 1981). As of December 1981 (the latest available listing), there have been eight chemicals whose RPAR's have been completed. Table 3 lists these chemicals.

The EPA has also instigated a pre-RPAR process. This is EPA's initial risk investigation that involves an intensive review of the scientific studies that suggest the RPAR risk criteria have been exceeded by the chemical in question. A validation of these studies is conducted by agency scientists and their contractors. This list of pre-RPAR chemicals is extensive and is not included here; it is available from the U.S. Environmental Protection Agency.

b. Classification of Pesticides. A registered pesticide is classified into general use or restricted use categories based on its degree of hazard. Those pesticides which can be freely purchased at any retail outlets by members of the general public are classified by the EPA as "general use." General use pesticides can be applied by anyone "without any undue hazard to the applicator and environment, as long as the instructions on the label are followed carefully" (Ware, 1978). In comparison, "restricted use" pesticides are those that can be applied only by certified applicators and for specific purposes. (See Table 2.)

Our investigation into pesticides has been limited to the general use types, as these are the pesticides most commonly available for house and garden use. Technically, consumers should not have access to the restricted use pesticides. However, our studies

Table 2. FIFRA SUSPENDED OR CANCELLED PESTICIDES. (U.S. EPA, 1979.)

Please note that most of these compounds were not used in consumer products.

Pesticide	Action/Effect
Aldrin	most uses cancelled
Arsenic trioxide	unacceptable for home use in excess of 1.5% (labeling)
Basic copper arsenate	voluntary cancellation
BHC	all registered products of non-gamma isomer eliminated (gamma isomer is called lindane)
Bithionol	products intended for skin contact or household use cancelled
Chloranil	voluntary cancellation
Chlordane	most uses cancelled, except termite control and dipping of roots and tops of non-food crops
Chlorobenzilate	cancelled, except for use on citrus crops under certain conditions
DBCP	all uses suspended except on pineapples in Hawaii
DDD (TDE)	cancelled
DDT	cancelled, except for emergency authorizations
2,4-D	labeling precaution for use on forage fields
Dieldrin	most uses cancelled
Disinfectants	cancelled: any products bearing labeling involving the terms "germ proofing," "germ proofs," and "germ proof"
Endrin	most uses cancelled
Fluoroacetamide	for use only inside sewers against Norway and roof rats, by certified applicators
Heptachlor	most uses cancelled -- see chlordane for exceptions
Kepone	all registered products cancelled
Lindane	use in vaporizers cancelled
Mercury	most uses cancelled -- can be used on textiles and fabrics intended for continuous outdoor use, on freshly sawn lumber, in water-based paints and coatings, etc.

(continued)

Table 2. FIFRA SUSPENDED OR CANCELLED PESTICIDES. (Continued)

Pesticide	Action/Effect
Metaldehyde	special warning, label required
Mirex	all registered products cancelled, except for non-aerial application to control ants on pineapples in Hawaii
OMPA	voluntary cancellation
Parathion	must be packed in one-gallon containers or larger, with correct safety label
PCBs	elimination of all use as active or inactive ingredient
Phenarzine chloride	voluntary cancellation
Polychlorinated terphenyls	same as PCBs
Predacides	can be used by federal agencies only on emergency basis, under certain conditions
Safrole	voluntary cancellation
Seed treatments	must contain dye or discoloring agent, except for use solely as planter box treatment
Silvex	chlorodioxin contaminants not allowed; many uses suspended (including home and garden use)
Sodium arsenite	unacceptable for home use in excess of 2%.
Sodium cyanide	all uses for mammalian predator control cancelled and suspended (except for use in M-44 under certain conditions)
Sodium fluoride	cancelled for home use if in excess of 40%
Sodium fluoroacetate	cancelled and suspended for use in mammalian predator control
Strobane	voluntary cancellation
Strychnine	cancelled and suspended for use in mammalian predator control
2,4,5-T	chlorodioxin contaminants not allowed; some uses suspended (including liquid formulations for use around the home); some uses cancelled (including granular formulations for use around the house)
Thalluim Sulfate	cancelled and suspended
Toxaphene	most uses on lettuce and cabbage cancelled

Table 3. PESTICIDE R.P.A.R.s COMPLETED
(U.S. EPA, 1981)

Chemical	Criteria Possibly Met or Exceeded
Amitraz	oncogenicity
Chlorobenzilate	oncogenicity, testicular effects
DBCP	oncogenicity, reproductive effects
Dimethoate	oncogenicity, mutagenicity, feto-toxicity, reproductive effects
Endrin	oncogenicity, teratogenicity, reduction in endangered species and non-target species
Pronamide	oncogenicity
1081	acute toxicity to mammalian and avian species, reduction in endangered and non-target species, acute toxicity without antidote
2,4,5-T/Silvex	oncogenicity, teratogenicity, and feto-toxicity

have shown that banned or restricted pesticides are commonly found in households (see Report C of this series). Perhaps the consumer bought some of these products prior to their cancellation or restriction, or may have received restricted materials from a friend. In some cases, it is still legal to use up existing stocks -- in other areas, these pesticides should not be used. This problem of disposal of pesticides is covered more thoroughly in Reports A and E of this series.

c. Labeling and Packaging. FIFRA also controls the labeling and packaging of pesticides. Containers must be conspicuously labeled with the following information:

- Name, brand, or trademark;
- Directions for use which will both be effective and still protect health and the environment;
- Ingredient statement, with name and percentage of each active and all inert ingredients;
- A statement of the use classification under which it is registered;
- The name and address of the producer; and
- Warning or caution statements, as follows:
  - Human Hazard "Signal" Word - Based on certain toxicity categories, signal words must be placed prominently on the front label: "DANGER" for products with extremely high toxicity (low, LD_{50} or LC_{50}*); "WARNING" for median toxicity; "CAUTION" for slight toxicity;
  - Child Hazard Warning -- Every pesticide must bear the statement "Keep out of Reach of Children" on the front label; and
  - Precautionary Statements -- Where human hazard exists, certain statements must be placed on the label; where acute LD_{50} is 100 or less for mammalian oral or fish, the statement "This Pesticide is Toxic to Wildlife or Fish" is required on the label.

Pesticides used in residential applications are required to have special packaging that is "significantly difficult for children under five years of age to open or obtain a toxic or harmful amount...within a reasonable time, and that is not difficult for normal adults to use properly" (40 CFR 162.16). The criteria for requiring special packaging include:

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*Toxicity measurements are explained in Appendix B.

- Acute dermal LD_{50} of 2000 mg/kg or less;
- Inhalation LD_{50} of 2 mg/l or less;
- Corrosive to the eye or skin; and
- Acute oral LD_{50} of 1.5 g/kg or less.

B. USE OF PESTICIDES IN HOME AND GARDEN

1. Volume Estimates

How widespread is pesticide use by private householders? There are a number of ways to quantify pesticide use, including percentage of total use, value of the market, application rates and quantities used.

a. Use Percentages. A survey of pesticide usage (Rumker, 1974), which considered only 25 selected compounds, found that home and garden applications accounted for 12 percent of the total use. In a study of three urban areas -- Philadelphia, Dallas, and Lansing, Michigan -- by Rumker *et al*. (1972), 92.5 percent of the respondents reported using pesticides. A national household pesticide usage study done by the EPA in 1977-78 (Savage *et al*., 1980) inventoried and interviewed households nationwide and found that 90.7 percent of all households use pesticides in their homes, gardens, or yards. Table 4 presents a summary of the results. Furthermore, they found that more than three times as many households in the U.S. use pesticides in their houses than on their yards (83.7 percent use pesticides in the house, 21.4 percent in the garden, and 28.7 percent in the yard). In a much more limited telephone survey, conducted in the Seattle metropolitan area as part of this project (see details in Report C of this series), 56 percent of respondents indicated that they had pesticides on hand.

b. Value of the Market. Estimates on the value of the market as a reflection of average U.S. use of pesticides in the home, lawn, and garden range from 7.5 percent of sales (U.S. EPA, N.D.), to 15 percent of sales (U.S. EPA, 1972) to 19 percent (McEwen and Stephenson, 1979). This latter source points out, however, that "Homeowner products are marketed in small packages and often in dilute concentrations," so these figures based on value may overestimate the market. The bulk of this market is concentrated in a limited number of products; 15 pesticide formulations (13 of them insecticides) account for 65.5 percent of all observed pesticide containers in a national study (Savage *et al*., 1980).

If we consider the additional use of pesticides in homes as applied by pest control operators (PCOs), the market grows significantly. These firms (11,000 interior PCOs and 15,000 exterior PCOs) did a $600 million business in 1973. Termite control alone accounted for the use of approximately 800,000

Table 4. USE OF PESTICIDES IN HOUSEHOLDS.
(Savage et al.,1980.)

Percentage	Type of Use
90.7%	of all households use pesticides in home, garden, or yard
83.7%	use pesticides in house
21.4%	use pesticides in garden (flower or vegetable)
28.7%	use pesticides in yard
20.6%	of all households store pesticides that have not been used in 12 months
16.4%	of all households use no-pest strips
35.8%	of all households use mothballs, flakes, or crystals
90.6%	of all households use disinfectants
28.4%	of all households use pet flea collars
13.3%	of all households use pet flea shampoos
13.1%	of all households use pet flea powders
2.0%	of all households use other pesticides on pets
41.1%	of all households bought pesticides at the grocery store, the site most frequently visited to purchase pesticides

30

lbs. of insecticides, almost 600,000 lbs. of which was chlordane (McEwen and Stephenson, 1979).

c. Application Rate. The previously mentioned study of suburban use in three U.S. cities by Rumker *et al.* (1972) estimated an application concentration of 5-10 lbs. of active ingredient per acre, and suggested that this represented "probably the heaviest pesticide application of any land area in the U.S."

A marketing analysis by Progressive Grocer (1979) found that 16.4 percent of the "homemaker base group" could be classified as heavy pesticide users in that they used house and garden insecticides at least once per week.

It should be noted, however, that the pesticidal active ingredients in lawn and garden products are primarily the least toxic insecticides and herbicides, and it is hard to compare this use with, say, agricultural use of generally far more toxic pesticides.

d. Quantities (Total Poundage). Table 5 presents the results of the Rumker *et al.* (1972) study for pesticide use by volume in three urban areas. Further efforts to quantify volumes sold or used at the national level are hampered by a reluctance on the part of manufacturers to release this kind of information in the highly competitive atmosphere under which they operate. The Rumker *et al.* study concluded that, "If the survey in the three cities is representative of use by American homeowners, the fact that a population of about 3 million used 750,000 lbs. suggests that outdoor use of pesticides around the homes may involve some 50 million lbs. of pesticides, a significant amount indeed."

2. Routes Into the Environment

Pesticides from home use can enter the environment in several ways: direct disposal (either by intentional dumping of contents or containers); runoff; atmospheric processes (drift and evaporation); and accidental spills. Table 6 describes these transport routes and their relative significance, as rated by Rumker *et al.* (1972).

a. Disposal. How are waste or excess household pesticides disposed of? According to the nationwide study of Savage *et al.* (1980), 28.6 percent of all households throw unused pesticides in the trash, while 5.0 percent dispose of them down the sink or toilet. The remaining 66.4 percent presumably use another disposal method or use up the pesticides as directed. The gutter, the driveway, and a hole in the back yard are possible methods of disposal, although no statistics are available. Empty pesticide containers are put in the trash by 67.6 percent of the households.

Table 5. ESTIMATED QUANTITIES OF HOME AND GARDEN PESTICIDES USED IN THREE URBAN AREAS (Rumker et al., 1972.)

Study Area	Population (000)	Single Family Dwellings	Home and Garden Pesticides Used, 000 Lbs of Active Ingredients/Year															
			Herbicides					Insecticides										
			Phenoxy	Dicamba	Atrazine	Other Herbicides	All Herbicides	Chlordane	Dieldrin	Dicofol	Dimethoate	Carbaryl	Malathion	Diazinon ®	Other Insecticides	All Insecticides	All Fungicides	All Pesticides
Philadelphia	3,866	879,413	79	(a)	(a)	10	89	50	(b)	10	11.5	(b)	95	(b)	32	198.5	46	333.5
Dallas	1,327	307,775	10.5	3.5	3.5	3	20.5	35	11	(b)	(b)	15.5	57.5	24	73	216	20	256.5
Lansing	272	56,658	(a)	(a)	(a)	(a)	12	3.5	(b)	(b)	(b)	1.7	3.7	(b)	5.6	14.5	2.8	29.3
Totals	5,465	1,243,846	89.5	3.5	3.5	13	121.5	88.5	11	10	11.5	17.2	156.2	24	110.6	429	68.8	619.3

(a) Included in "Other Herbicides"
(b) Included in "Other Insecticides"

Table 6. PESTICIDE TRANSPORT ROUTES.
(Rumker et al., 1972.)

Rank[a]	Route to the Environment	Relative Significance
1	Overland Drainage	
	● Emulsions in Water	greatest
	● Construction Sediment	moderate
	● Granular Formulation	low
2	Intentional Dumping of Leftover Materials	great (potentially)
3	Accidental Spills	great (potentially)
4	Container Disposal	great (potentially)
5	Atmospheric Processes	
	● Evaporation from Land	moderate
	● Evaporation During Application	low
	● Drift	
	individual	low
	commercial	moderate
6	Movement in Ground Water	low

[a] In descending order of importance.

b. Runoff. The formulation of the pesticide and how it is applied affects its propensity for entering the environment via runoff. Dry granular products applied with a spreader have a low pollution potential. According to Edwards and Glass (1971), the granules tend to lodge in the grass or ground surface and be trapped. Rain helps to settle and immobilize them. Spray products in small containers are unlikely to contaminate their surroundings significantly. Overuse of aerosols and dusts from small containers is unlikely because of their relatively high cost.

Liquid insecticides used on lawns, or pesticides used on trees growing over pavement, on the other hand, are more likely to be transported by runoff and go directly into streams or sewer systems. After pesticides have been applied, the emulsifiers evaporate, leaving the pesticide to adsorb and anchor onto the plant. If it rains before the pesticide emulsion has broken, however, the pesticide may be washed off. The time of mobility is determined by the emulsion used, but it is believed to be about three to five days (Rumker et al., 1972).

Erosion of sediment and subsequent transport of pesticides is less frequent in established urban/suburban areas than in agricultural lands, due to the semi-permanent nature of lawns. Only very heavy rains which result in flooding are likely to produce sediment transport in lawns. It is possible to get sediment transport during new construction, tilling of garden soils, etc.; if these soils had been exposed to pesticides, the potential exists for residues or degradation products to enter the water.

The final factor which can affect pesticide transport in runoff is the time of application. Investigators have determined that the average householder applies pesticides at a very distinct time, concentrated during the four weekends in May, with some applications the last weekend in April and the first weekend in June (Rumker et al., 1972). Thus, there are six or seven weekends each year during which 85-90 percent of all yard and garden pesticides are applied. If it rains these weekends, the pesticides are not applied. But if heavy rains producing large amounts of runoff occur soon after pesticide application, pesticides can be carried off. A dry spring weekend followed by a wet week has the greatest potential for contamination of runoff waters.

c. Other Routes. The amount of household pesticides entering the environment via atmospheric processes and accidental spills is unknown and extremely difficult to quantify. There are other indirect means by which pesticides can enter the environment from residential sources, also extremely difficult to quantify. Garden pesticides may become part of the waste stream when fruits or vegetables sprayed with them are washed in the sink or ground up in the garbage disposal. Although most garden pesticides degrade rapidly, Hathaway (1980) notes that pesticides are commonly stored near basement drains or utility sinks, where they could be spilled and washed into the wastewater disposal system. Pesticides are washed from clothes and enter the household wastewater. Most of these methods undoubtedly result in very low concentration levels of pesticides and probably are not detectable with present analytical methods.

C. ENVIRONMENTAL IMPACT

1. Degradation and Persistence

Very little is known about what happens to pesticides after application under actual field conditions. This makes it difficult to define how pesticides impact the environment.

There are several aspects to this problem:

- Pesticides applied in the field will come in contact with non-target organisms as well as target species. Toxicity towards non-target organisms appears to have been studied more for some pesticides than for others.

- Information on degradation pathways is very elusive. It is almost impossible to produce general conclusions for any pesticide given the enormous variety of chemical, physical, and biological changes that can occur under various conditions, not to mention all the possible interactions that could occur. Figure 1 gives an idea of this complexity.

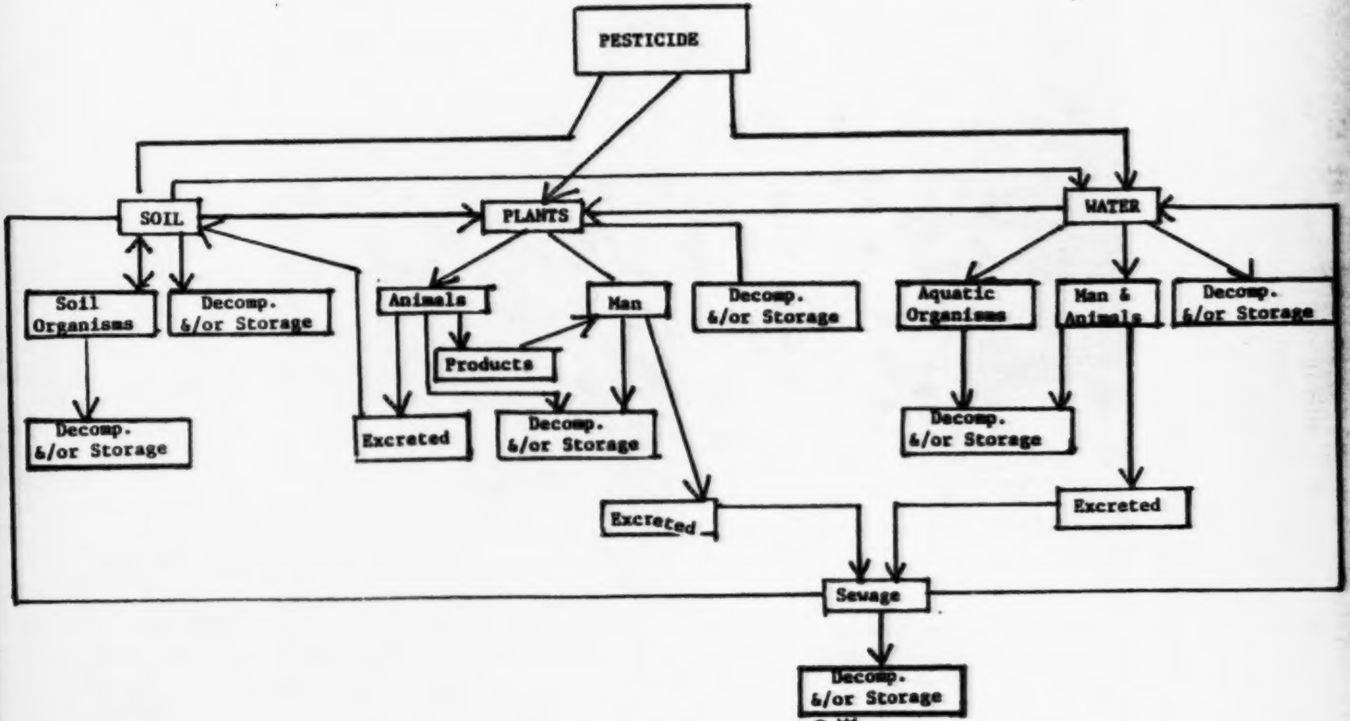
- Persistence times refer only to the parent compound; there is no guarantee that the degradation to harmless substances has occurred at the end of this time. Primary metabolites of some pesticides are even more toxic than the parent compound. For example, the major intermediate in the degradation of carbaryl is 1-naphthol. This is at least as toxic, if not more so, than carbaryl itself. It has been found to be of variable stability, depending on conditions (Stewart et al., 1969).

- In many cases, analytical methods have been devised to monitor for the parent compound only. They have limited value in determining breakdown products and, thus, the total environmental impact of the chemials.

- Possible synergistic interactions between two or more pesticides or their products in the environment are basically unknown and extremely difficult to study.

FIGURE 1

A SIMPLE CONCEPTUAL MODEL OF POSSIBLE RELATIONSHIPS BETWEEN PESTICIDES AND ENVIRONMENT. (Rumker et al., 1972)



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Degradation rates and persistence times are inversely related. The rate of degradation will obviously affect how much pesticide is remaining. In-depth studies have shown for degradation in soil that basic soil characteristics are most important in determining the rate. These characteristics then determine kinds and amounts of organisms present. The basic chemical and physical nature of the water will determine degradation rates and persistence. For instance, the amount of colloidal clay in the water will affect how much of the pesticide is adsorbed onto these particles and removed from the water column. In both soil and water, pesticides are subject to a variety of physical environmental factors, such as temperature, pH, and kind and quality of light. These factors, taken with the inherent stability of the molecule itself, will determine a pesticide's persistence and degradation.

2. Short- and Long-Term Effects

There has been a significant change in use patterns in recent years which has affected short- and long-term environmental effects of household pesticides. In the past, organo-phosphates, such as methoxychlor, DDT, and dieldrin, were used much more extensively -- all have a relatively low acute toxicity and a long persistence time. Now, however, the carbamates and organophosphates, such as Diazinon®, malathion, parathion, are much more common. In fact, in this text, we have reviewed 12 organophosphates and carbamates, as opposed to only two organo-chlorines. The organo-phosphates and carbamates have relatively high acute toxicity and shorter persistence time.

These pesticides with short-term effects (i.e., high acute toxicity) can, under certain conditions, constitute a serious health hazard to the aquatic and soil environment. A point source of these chemicals, such as a sewage treatment plant outfall or a storm drain, could be heavily loaded with acutely toxic compounds. This could weaken the aquatic organisms to the point that physical changes, scouring, or low levels of other chemicals could become more lethal. In most instances, however, effects of pesticide transport resulting from heavy water flow probably have little effect on the aquatic environment, due to the massive factor of dilution.

Those pesticides with long-term effects (longer persistence times) can accumulate in many aquatic or soil organisms even at extremely dilute concentrations. Exposure will therefore result in some portion of the pesticide being taken up by the soil or water organism immediately. The remaining portion, often larger, will bind to inorganic and organic particles and be released into the food chain at a slower rate. Until we know more about the fate of degradation products, however, it is difficult to accurately foretell the effect of these compounds on the environment.

Long-term, low level (sublethal) exposures to some pesticides have been shown to reduce photosynthesis in marine and freshwater algae and to accumulate in common zooplankton -- at a rate of several thousand times the concentration in ambient water within one day for some organo-chlorides (Rumker et al., 1972). Aquatic insect larvae exhibit a wide variety of responses. Fish respond to these long-term, low level exposures in a number of ways, the end result being a reduction in growth rate, and altered reproductive potential. These responses result in a change in species composition for the community. All aquatic organisms appear to suffer reduced fitness and increased susceptibility to disease or the effect of parasitic infection as a result of long-term, low level exposure.

The primary health hazard to humans is through careless use of the acutely toxic carbamate and organo-phosphate compounds. Standing in spray drift or other physical contact with concentrated solutions will pose a threat (Rumker et al., 1972). The other potential for human harm, especially to children, is by accidental ingestion of these compounds.

D. ADDITIONAL COMMENTS

Our original intent in reviewing these pesticides and their effects was to prioritize the 33 commonly used pesticides according to potential hazards from disposal. We could then take the most hazardous pesticides and focus on them as the chemicals of major concern in any collection program or other activity. We considered that the following criteria should be taken into account in a prioritization process: total quantity used locally; concentration in available products; acute and chronic effects on humans; acute and chronic effects on other organisms, particularly marine organisms; bioaccumulation; persistence; degradation products and their environmental effects; and synergistic effects with other chemicals.

Because of insufficient and unreliable data -- and the following issues -- this intended process was abandoned.

1. EPA Registration Process

The entire process of registering pesticides (and thereby giving implicit approval of safety) has some severe problems. The original legislation setting up this process provided blanket re istration with no commensurate testing for safety. In 1972, amendments were passed to FIFRA which required the EPA to register all pesticides, based on chronic as well as acute impacts to health and the environment. Less than five percent of the 35,000 or so commercial preparations that were already in use at the time have been tested or retested to meet those 1972 standards. EPA registration of these 33 pesticides provided little information about their safety when compared to other pesticides.

2. Testing Program

The safety of newly registered commercial preparations is questionable because of problems with EPA's registration process itself. Much of the information that the chemical companies present to the EPA for registration of pesticides is in the form of brief selected summaries, rather than complete data that would allow for independent peer review. Furthermore, many of the safety tests that were done are now being considered invalid because they were done by the nation's largest safety testing, Industrial Biotest (IBT) Laboratories of Northbrook, Illinois. The EPA has found that up to 94 percent of this testing company's safety results are invalid (Moe, 1981). Several of the pesticides on our list, including 2,4-D, glyphosate, and dichlobenil, were tested by IBT. This is not an isolated incident -- serious deficiencies in the work of about 25 U.S. laboratories have been detected in the past four years by EPA investigators (Stackelberg, 1981). These faulty tests call into question all safety testing and complicate any attempt to prioritize these chemicals.

3. Chronic Tests

While acute toxicity data are readily available and widely accepted, chronic toxicity information and studies on breakdown products are less well documented and in many cases, contradictory. This complex area is still developing and clear-cut determinations are sometimes hard to make. Also, chronic toxicity and other long-term tests are expensive, in that they must by definition extend for a longer time. If not requested, some manufacturers have not been eager to fund such expensive tests or release potentially damaging results. EPA found that the Velsicol Chemical Company had suppressed an internal study linking chlordane and heptachlor to cancer. When charged, the company pleaded no contest (Foster and Dowie, 1982). These kinds of credibility questions lead to the contention that manufacturers and their consultants may be said to be a community of economic interest, and that this economic interest may not serve the best public interests of human or environmental health.

We decided against prioritizing the pesticidal chemicals for the following reasons:

- As mentioned above, the diverse and sometimes conflicting data available did not provide a firm basis for decision-making;

- The area of greatest concern in this study -- the long-term, cumulative effect issue -- is the area with the greatest gaps of information; and

- We felt our own expertise was too limited to make such fine judgements.

All pesticides are chemicals of concern, in that they are all toxic in some degree or another. The most currently available data is compiled here. Individuals must decide what is safe and what is not.

E. INFORMATION ON PESTICIDAL CHEMICALS

1. Study Methods and Scope

In deciding which pesticides to choose for review in this project, we disregarded RPAR and pre-RPAR listings and focused primarily on those pesticides which are most commonly used in the home and garden. We got this information from two sources: an EPA study of household pesticides, and our own informal shelf survey.

The previously mentioned household pesticide usage study (Savage *et al*., 1980) found that the *most frequently used* pesticides in descending order are:

- Disinfectants;
- Mothballs and flakes;
- Pet flea collars;
- No-pest strips; and
- Other pet pesticides (flea shampoos and powders).

The same study (Savage *et al*., 1980) also determined that the *ten most commonly used* pesticides in order of *amounts* used are:

- Dichlorvos
- Resmethrin
- Pyrethrin
- Chlordane (no longer available to general public)
- Carbaryl (Sevin®)
- 2,4,-5-5/Silvex (most uses of Silvex now cancelled)
- Diazinon®
- Baygon® (Propoxur)

- Malathion

- Metaldehyde

The other source used in choosing the pesticides to review in this project was an informal survey done by our research team of those pesticides available on the shelves of a large chain hardware store and supermarket in Seattle. Table 7 provides a list of these pesticides, their active ingredients and concentrations, as listed on their labels.

Using these sources, we compiled a list of commonly used pesticides. Table 8 lists the 32 pesticides of five general types reviewed in detail in Tables 9-13. (As mentioned previously, we have chosen to review the pesticide disinfectants and wood preservatives in the Household Cleaners and Paint Products sections, respectively.) Although restricted use pesticides are frequently used in the home and garden by professional pest control operators, we did not deal with them because their application and disposal are not the concern of the lay householder.

Technical information on the health and environmental effects of household pesticides has been compiled in Tables 9-13, which follow. Each pesticide was investigated for information contained in the tables' subheadings -- Common Name, Trade Name, Pesticidal Action, Acute LD_{50} for Rats, Health Effects, Environmental Effects, Environmental Fate, Regulatory Status, and Disposal Recommendations. Whenever possible, we have included information concerning acute and chronic toxicity data relevant to humans, toxicity data relating to other organisms, such as fish and bees, and information on environmental fate including persistence and degradation pathways. There is an enormous amount of material available, and we have only surveyed some of it. These tables cannot be considered complete.

Three "keys" will help you understand the information contained in the following technical information tables:

- Subscripted numbers refer to the sources from which the information was taken. A key to these sources can be found in the Citations section at the end of the tables on page 49. Complete listings of these citations are found in the References section at the end of the report on page 179.

- Abbreviations and unfamiliar terms can (usually) be found in the List of Abbreviations and Glossary of Terms on pages 221 and 213, respectively, in Appendix C.

- Readers without chemistry background may find Appendix A (page 190) to be helpful in understanding the chemical interrelationships. Toxicity ratings and determinations are explained at length in Appendix B (page 201).

Table 7. EXAMPLES OF RETAILED PESTICIDES.
Pesticides found during an informal survey at Ernst Hardware Store, University Village Shopping Mall, in Seattle, Washington, in July, 1981.

Manufacturer	Name	Active Ingredient	Concentration (by weight)
Corry's	Snail & Slug Death	Metaldehyde	2%
Ortho	Bug-geta Slug & Snail Pellets	Metaldehyde	3.25%
Lilly/Miller	Slug, Snail and Insect Killer Bait	Metaldehyde	2%
		Carbaryl	5%
Farnham Cos.	Slug-Jail	Metaldehyde	3%
		Carbaryl	5%
d-Con	Mouse-Prufe	Warfarin	0.054%
Strike	Rat & Mouse Killer	Warfarin	0.025%
		Prolin	0.025%
Grants	Ant Control	Arsenic Trioxide	0.46%
Ortho	Kleen-up Weed & Grass Killer	Isopropylamine Salt of Glyphosate	5%
Ortho	Triox	Prometon	1.86%
		PCP	0.86%
		Other chlorinated phenols	0.08%
Ortho	Orthene Insect Spray	Acephate	15.6%
Ortho	Rose & Floral Dust	Carbaryl	3%
		Malathion	4%
		Folpet	5%
		1,1 bis(p-chlorophenyl) 2,2,2-trichloroethanol	1.5%
Ortho	Tomato & Vegetable Insect Spray	Pyrethrins	0.03%
		Rotenone	0.16%
		Butacide	0.128%
		Other cube resins (Rotenoids)	0.238%
Ortho	Home Pest Killer	Diazinon	0.5%
Lilly/Miller	Insect Dust	Diazinon	4%
Lilly/Miller	Wasp, Hornet, Ant & Roach Killer	Baygon (Propoxur)	0.5%
Ortho	Sevin	Carbaryl	5%
Ortho	Orthocide	Captan	47.3%
Ortho	Diazinon	Diazinon	25%
Ortho	Fuginex	Triforine	6.5%
Ortho	Isotox	Acephate	8%
		Kelthane (dicofol)	3%

(continued)

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Table 7. EXAMPLES OF RETAILED PESTICIDES.
Pesticides found during an informal survey at Ernst Hardware Store, University Village Shopping Mall, in Seattle, Washington, in July 1981. (Continued)

Manufacturer	Name	Active Ingredient	Concentration (by weight)
Ortho	Systemic Rose & Floral Spray (Synthetic Pyrethrin)	Acephate Resmethrin (Related) Triforine	0.25% 0.1% 0.014% 0.1%
Ortho	Lawn Insect Spray	Dursbanch (chlorpirifos)	5.3%
Ortho	Dyrene	Dyrene	50%
Lilly/Miller	Rotenone	Rotenone Captan Benomyl	1% 5% 50%
Lilly/Miller		Sevin	5%
Lilly/Miller		Diazinon	1.94%
Lilly/Miller		Malathion	57%
Lilly/Miller	Rose, Shrub	Dy-syston (disulfoton)	1%
Lilly/Miller	Rose & Floral Dust	Carbaryl Rotenone	5% 1.5%
Lilly/Miller	Ant & Roach Killer	Baygon (Propoxur)	0.5%
Lilly/Miller	House & Patio Insect Killer	Synthetic Pyrethroid Synthetic Pyrethroid	0.25% 0.034%
Lilly/Miller	Weed Bomb	2,4-D Dicamba dimethylamine salt of MCPP	0.287% 0.289% 0.13%
Lilly/Miller	Noxall Vegetation Killer	Prometon 2,4-D	3.6% 1%
Ortho	Weed-B-Gon	dimethylamine salt of 2,4-D dimethylamine salt of MCPP	11.5% 11.6%
Ortho	Weed Preventer	DCPA	5%
Ortho	Contax Weed & Grass	Na-dimethylarsinate Cacodylic Acid	10.4% 1.77%
Ortho	Casoron Granules	Dichlobenil	2%
Ortho	Hornet & Wasp Killer	2(1-methylethoxy)methyl-carbonate	0.5%
Ortho	Household Insect Killer	Resmethrin	0.25%
Farnham	Killer Kane	2,4-D	38.5%
Sergeant	Flea & Tick Powder	Carbaryl	5%
Sergeant	Flea & Tick Spray	Carbaryl	0.5%
Strike	House and Kennel Fogger	Ronnel Dichlorvos	2% 0.47%
Ortho	Indoor Plant Spray	Pyrethrins	0.02%

(continued)

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Table 7. EXAMPLES OF RETAILED PESTICIDES.

Pesticides found during an informal survey at Ernst Hardware Store, University Village Shopping Mall, in Seattle, Washington, in July, 1981. (Continued)

Manufacturer	Name	Active Ingredient	Concentration (by weight)
Ortho	Indoor Plant Spray (continued)	Rotenone	0.13%
		Other cube resins	0.13%
		Butacide	0.25%
Hartz	Flea Collar	Gardona (Stirofos)	13.7%
Safeway	Flea Collar	Carbaryl	8.5%
Sergeant	Flea Collar	Naled	15%
		Baygon	4.2%
Sergeant	No-Pest Strips	Vapona	20%
Black Flag	Ant & Roach Killer	Baygon	0.5%
		DDVP	0.186%
Raid	Ant & Roach Killer	Baygon	0.665%
Raid	Crawling Insect Killer	DDVP	0.186%
		Chlorpyrifos	0.5%
Raid	Flea & Tick Killer	(Synthetic Pyrethrin)--	0.4%
		Tetramethrin related	0.28%
Raid II		(Synthetic Pyrethrin) SBP-1382	0.2%
		(Synthetic Pyrethrin) Allethrin	0.125%

Table 8. PESTICIDES: CHEMICALS REVIEWED.
The following chemical ingredients are reviewed in the Product Technical Information Tables 9-13.

I. INSECTICIDES -- Table 9

- A. Organophosphates
  - Acephate
  - Chlorpyrifos
  - Diazinon ®
  - Dichlorvos
  - Disulfoton
  - Malathion
  - Naled
  - Ronnel
  - Stirofos
  - Trichlorfon
- B. Carbamates
  - Carbaryl (Sevin ®)
  - Propoxur (Baygon ®)
- C. Organochlorines
  - Lindane (Kwell ®)
  - Methoxychlor
- D. Organosulphurs
  - Ovex
- E. Botanicals/Microbioals/ Synergists
  - *Bacillus thuringiensis*
  - Piperonyl butoxide
  - Pyrethrin
  - Rotenone

II. HERBICIDES -- Table 10

- A. Arsenicals
  - Arsenic trioxide/ Cacodylic acid
- B. Chlorophenoxy Acids
  - 2,4-D
- C. Triazines
  - Prometone
- D. Benzoic Acid Derivatives
  - Dicamba
  - Dichlobenil
- E. Phenol Derivatives
  - Pentachlorophenol
- F. Glycene Derivatives
  - Glyphosate (Roundup ®)

III. FUNGICIDES -- Table 11

- A. Dicarboximides
  - Captan
  - Folpet
- B. Benzimidazoles
  - Benomyl
- C. Triazines
  - Anilazine

(continued)

Table 8. PESTICIDES: CHEMICALS REVIEWED. (continued)

IV. RODENTICIDES -- Table 12

- A. Coumarins
  - Warfarin (D-Con®)

V. MULLUSCICIDES _ Table 13

- A. Aliphatics
  - Metaldehyde

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Table 9: INSECTICIDES

A. Organophosphates

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Acephate (Orthone®)	Cholinesterase inhibitor	866[1,5], 945[4], 900[3] (2,000[1], 2,000 (Rabbits))	• Acute effects-typical organophosphate (see Malathion). • Chronic effects-no info yet.	• Toxic to bees.[19] • Toxic to birds- LD_{50}=106 mg/kg metabolized to methamidophos- • LD_{50}= 8 mg/kg.[20]	• Do not mix with alkali, Cu or S.[4] Possible metabolite= methamidophos which is more toxic than acephate.[20] • Moderately persistent.[19]		• Treatment with alkali (Turn in)[3].
Chlorpyrifos (Dursban® Lorsban®)	Cholinesterase inhibitor.	97[1], 135-163[3] (2,000[1], 2,000[3]) (Rabbits)	• Acute effects-typical OP (see malathion). • Chronic effects-no info yet.	• Toxic to fish LC_{50}-[3] rainbow trout=0.02ppm golden shine=0.035ppm mosquito fish=0.215ppm green sunfish=0.022ppm • Relatively toxic to birds LC_{50} = 12 (Pheasant) = 75 (Ducks)[8]	• Moderately persistent in soil.[8]		• Turn in. (Treat with oxidants).
Dichlorvos (Vapona®, DDVP)	• Cholinesterase inhibitor. • Very high vapor pressure, so good fumigant. Incorporated into pest strips.	25[1], 56[4], 25-30[3] 50-80[3], 80[2], (59[1], 75-900[3], 131-218[3] (rabbits), 107[2]). • No effect level Rat 0.5, Man 0.033, Dog 0.37[2]	• Acute effects-typical O.P. (see Malathion) • Found to cause increased airway resistance. • Found mutagenic in bacterial cultures[15]. • Found teratogenic in rats but not several other mammals.[16]	• Toxic to fish-LC_{50}[3] bluegill-0.7 ppm,[3] Toxic to bees (A)[3].	• Rapidly hydrolyzed in pure water. → no toxic residues.	Pre RPAR review.	• Turn in. (Treatment with alkali).

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PESTICIDES TECHNICAL INFORMATION

Table 9: INSECTICIDES

A. Organophosphates (con't)

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD$_{50}$ for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Diazinon® (Spectracide®)	Cholinesterase inhibitor.	66[1], 150[4], 300-600[3], 150-600[3], 108[2], 300[5] (379[1], 500-1200[3], 200[2]) • No effect level -Rat-0.1, -Monkey-0.05, -Dog-0.02, -Man-0.02 [2].	• Acute effects-typical OP (see Malathion). • Contains small quantities of a highly toxic impurity known as sulfotepp. Sulfotepp is a potent cholinesterase inhibitor. • Hydrolysis of concentrated amounts of diazinon may be responsible for greater than anticipated toxicity to emergency response personnel.*	• Toxic to Ducks & Geese.[4,3,9] • Toxic to fish LC$_{50}$-bluegill=0.03 ppm[3] • Toxic to bees (A)[3]	• Persistence ~5 mos[3] (Hydrolysis→Sulfotepp) (Oral LC^{50}=5) • Does not bioaccumulate.[9]		• Turn in. (Treat with alkali)[3].
Naled (Dibron®)	Cholinesterase inhibitor.	430[1,4,3]. (1,100[1], 800-1100[3]).	• Acute effects-typical OP (see malathion). Chronic effects-no info found yet.	• Toxic to bees[4] (-A)[3]. • Toxic to fish- LC$_{50}$ brook trout= 0.078ppm[3]. LC$_{50}$ rainbow trout= 0.24 ppm[8]. • Causes 50-70% decreases in marine phytoplankton. Low to moderate toxicity to birds.[8] (LC$_{50}$ quail = 2100 mg/kg, LD$_{50}$ duck = 52 ppm)	• Breaks down in water[4]. • Hydrolyzes relatively rapidly in alkaline medium somewhat more slowly in water.[3] • Degraded by sunlight.[3]		• Turn in. (treatment with alkali).[3]

* Diazinon®/ Health effects-chronic effects-Found teratogenic in rat fetuses & chick embryos.[16,21] Breakdown products of diazinon®-mutagenic in bacterial culture.[22]

PESTICIDES TECHNICAL INFORMATION

Table 9: INSECTICIDES

A. Organophosphates (con't)

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Malathion (Cythron®)	Cholinesterase inhibitor.	885[1], 1650[4], 1375[2,5], 1400-1900[3], 1400-2800[3], (4000[1], 4000[3], >4444[2]) - No effect level: - Rat 0.5 mg/kg/day(2). - Man 0.2 mg/kg/day.	Organophosphates are absorbed via ingestion, inhalation & dermal contact. They are degraded in the liver & other tissues within hours. Degradation products excreted in urine & feces -- do not accumulate. *	•Toxic to fish[4,9]. LC_{50}-brooktrout= 0.02 ppm[3]. minnow=12.5ppm. •Highly toxic to bees-(A)[1,9]. •Highly toxic to some beneficial parasites & predators including lady beetles, wasps, & green lacewings.[10] •In mammals, it is rapidly hydrolyzed in the liver & elsewhere. •Degradation products are readily excreted in the urine & feces.[9]	•Persistence< 3 mo.[3] •Easily degraded by soil microorganisms. •Reacts with heavy metals[4], especially iron.		7 (1-3)[3].
Stirofos (tetrachlorvinphos) ® (Cardona®, Rabon ®)	Cholinesterase inhibitor.	4000[1,4], 4,500[3]. (5000[1])	•Acute effects-typical organophosphate (see malathion). •Chronic effects-no info yet.	•Slight suppression of earthworm populations.[8] •Moderately toxic to fish. LD_{50} to harlequin fish =4.3ppm[8]. •Low toxicity to birds.[8]	• Hydrolyzes relatively quickly in alkaline medium.[3]		•Treatment with alkali. (Burial, trash[3]).

*(Malathion) - Health effects: Organophosphates are non-reversible cholinesterase inhibitors, i.e., interfere with transmission of nerve impulses. Acute symptoms include headache, dizziness, twitching, nausea and vomiting, broncoconstriction and bradycardia.[1,2,6] Chronic effects: a review study found malathion carcinogenic in rats.[14] Found to be teratogenic in chick embryos.[52]

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PESTICIDES TECHNICAL INFORMATION

Table 9: INSECTICIDES

A. Organophosphatus (con't)

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Disulfuton (Di-Syston®)	•Cholinesterase inhibitor. •Plant systemic soil application.[4]	•2[1], 4[4,3], 6-8[2], (20[1], 50[3], 15[2])	•Acute effects-typical organophosphate. (See malathion). Most acutely toxic of all pesticides in this review. •Chronic effects - no information found yet.	•Highly toxic to fish[4] LC_{50}-Bluegill=0.04ppm[3] •Toxic to bees (B).[3] •Causes decrease in marine phytoplankton.[8]	•Activated by water[4] •Persistence <3 mo[3], although converted to sulfoxide which is fairly stable in soil.[8]		•Turn in.
Trichlorofon (Dylox® Neguvon®, Anthon)	Cholinesterase inhibitor.	450[1], 650[4,3], 450-500[3], 630[2] (2000[1,2], >2800[3]). •No effect level Rat 2.5 mg/kg/day, Dog 1.25[2].	•Acute effects-typical OP, see malathion. •Chronic effects -no info found yet.	•Highly toxic to birds.[4] •Low toxicity to fish- LC_{50}-rainbow trout= 160ppm[3]. fathead minnow= 180ppm[3]. •Relatively non-hazardous to bees.[3]	•Hydrolyzes → Dichlorvos→→etc.[3] 100% hydrolyzed in 24 hours to non-toxic products.[3]	Pre-RPAR review.	•Turn in. (Treatment with alkali).[3]
Ronnel (Korlan® Trolene®)	Cholinesterase inhibitor. Animal systemic.	906[1], 1740[4,3], 1000-3000[3], 1250[2]. (1000[1], 5000[3,2]). •No effect level -Rat=0.5, -Dog=1.0.	•Acute effects-typical OP (See malathion).[4] •Irritating to eyes.[4] •Potential contaminant with TCDD. (Watson pers. comm). Chronic effects-no info yet.	•Toxic to bees.(B)[3] •Low toxicity to fish & amphibians.[8]	•Non-persistent in soil.[8] •Breakdown by soil microorganisms.[8]	Pre RPAR review.	•Turn in (Treatment with alkali).

Table 9: INSECTICIDES

B. Carbamates

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Carbaryl (Sevin®)	Broad spectrum. (Cholinesterase inhibitor)	400[4], 307[1], 500[5,3], 400[3], 850[2], (2000[1], >500[3], >2000[3], >4000[2])	• Carbamates absorbed via ingestion, inhalation & dermal contact. Actively metabolized by liver. Degradation products excreted by liver & kidneys. • Carbamates are cholinesterase inhibitors with symptoms similar to OP's.[6] **	• Highly toxic to bees.[4,27] • Will increase mite populations.[4] • Mod. toxic to fish LC_{50}-trout=1.5ppm. fathead minnow=13 longnose killifish=1.75 bluegill=5.6 white mullet=4.25	• Moderately persistent.[28] • Stable to UV[3]. • Does not bioaccumulate, it is degraded by chemical hydrolysis and microbial activity.[9]		• Turn in.[3] • Treatment with alkali.[3] • Treat with alkali and bury.[12]
Propoxur (Baygon®)	Cholinesterase inhibitor especially, on roaches.	100[4,3], 95[1], 90[5], 83[2], (1000[1], <200[3], >2400[2])	• Acute effects: typical carbamate. (see carbaryl B1).	• Chronic effects: mutagenic in bacterial systems.[29] In presence of nitrite in environment, propoxur forms nitrosopropoxur, which is mutagenic in bacteria[30], carcinogenic in rats[31], and causes single strand breaks in DNA of human skin cells.[32] • Harmful to bees and fatal to birds feeding in treated areas.[19] • LC_{50} fathead=0.025[3].	• Forms nitrosopoxur in contact with nitrite in environment. Long residual activity.[19]		1-3(7)

** Chronic effects-carbaryl was found teratogenic in dogs & mice.[23] Causes spontaneous abortion in monkeys.[24] Derivative of carbaryl called nitrosocarbaryl. Mutagenic in Ames Test[25] and carcinogenic in rats.[26]

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PESTICIDES TECHNICAL INFORMATION

Table 9: INSECTICIDES

C. Organochlorines

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Lindane (Kwell®)	Interfere w/ axionic transmission. Used as head louse shampoo. Typical organochlorine (see methoxychlor)	90^3, $88^{2,5}$, 200^3, 76^1 • No effect level Rat = 1.25 mg/kg/day.	• Readily absorbed through skin. Eliminated slowly but completely. • Implicated in cases of hypoplastic anemia.[2] • Chronic effects: long-term administration to rats found to cause teratogenic, carcinogenic & central nervous system effects.[20,30]	• Toxic to fish-LC_{50} rainbow trout=0.05ppm[3] =0.23ppm • Toxic to bees.[3] (A.) • Some bioaccumulation, but less than methoxychlor.[8]	• Persistent in soil, but least of organochlorines.[8] • Half-life=1.2 yrs. 95% gone-6.5 yrs.[8] • Degrades quickly in anaerobic conditions.[8]	RPAR-last PD issued 7/3/81.	• Incinerate. (Turn in).[3]
Methoxychlor (Marlate®, DMDT)		• 5000^1, 6000^3, $5000\text{-}7000^{3,2}$ • No effect level Rat-10mg/kg/day.	• Absorption by ingestion. • cute effects--Organochlorines interfere with axonal transmission of nerve impulses. Symptoms include headache, dizziness, twitching, convulsions, nausea & vomiting, respiratory depression.[6] **	• Toxic to fish-LC_{50} rainbow trout=0.052 ppm guppies =0.12 ppm[2] • Relatively non-hazardous to bees.[2] • Greatly concentrated in algae & bacteria in the water.[8] • Rapidly borken down in warm-blooded animals.[8]	• Persistent in soil-but less than DDT.[1]		• Incinerate. (Bury).[3]

**Methoxychlor is metabolized by a different path from DDT, also has fewer chlorines, so has much shorter biological half-life.[2] Stored in body fat for much shorter time than DDT.[2] No information on chronic effects.

PESTICIDES TECHNICAL INFORMATION

Table 9: INSECTICIDES
D. Organosulphurs

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Ovex (Orotran®)	miticide	•2000[3,1]	•No information.	•Relatively non-toxic to bees.[8] Bioaccumulates in hens.[8] Low toxicity to fish-LC_{50} bluegill = 780[3].	•No information.		•Burning, burial (incineration).

Table 9: INSECTICIDES
E. Botanicals, Microbials, Synergists

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Pyrethrins (Resmethrin (LD_{50}=1,500 & Tetramethrin (LD_{50}=20,000) are synthetic pyrethroids).	•Causes rapid paralysis-mechanism not known! •Synergists used to prevent insect degradation of pyrethrins & recovery.	200[1], 570[3]	•Acute effects-contact dermatitis, occasionally severe and phylactic reactions.[2] •No information on chronic effects.	•Toxic to fish-LC_{50} Rainbow trout=0.054 ppm. •Relatively non-hazardous to bees.[3]	•Highly unstable in light, moisture & air[3]. •Insecticidal activity easily destroyed.[3]		•Bury (Burn, ground surface disposal)[3]. No real problem.
Rotenone (Cube resins are also rotenoids).	•Blocks oxidative phosphorylation. •High toxicity to insects, low to mammals.	60[1], 25-132[3]	•Absorption by ingestion, inhalation[2] (most hazardous)[2] and dermal contact. •Acute effects: dermatitis, gastrointestinal irritation[2], respiratory depression. •Chronic effects - not found yet.	•Highly toxic to fish-LC_{50} bluegill=0.022[3]. •Relatively non-toxic to bees.[3]	•Breaks down rapidly in soil & water.[1]		•Treat with alkali (incinerate, burn)[3].

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PESTICIDES TECHNICAL INFORMATION

Table 9: INSECTICIDES

E. Botanicals/ Microbials/Synergists

(con't)

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) *LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Bacillus Thuringiensis (Biotrol®, Thuracide®, Dipel®).	Bacterium whose spores cause diseases in insect larvae.	●Non-toxic[1] (disease specific to insect larvae, no effect on mammals).	●No known effects on health.	●Affects only leaf-eating insects, so harmless to beneficial insect predators & parasites, birds, bees, fish & mammals.	●Breaks down rapidly, non-persistent.		●Dilution (Burial)[3].
Piperonyl Butoxide (Butacide®)	Inhibits enzymes in the insects that would metabolize & detoxify the insecticide. Mostly used with pyrethrin.	7500[1,3]	●Conflicting evidence on carcinogenicity: ●NCI found not carcinogenic, adding that no conclusion drawn as to effects in combination with pyrethrins.[31] ●Piperonyl butoxide not carcinogenic alone but is in rats when in combination with freon.[32] ●Found to cause cancer in mice in another study.	●No information on this.	●No information on this.	pre-RPAR.	●Burial (burning).[3]

PESTICIDES TECHNICAL INFORMATION

Table 10: HERBICIDES

A. Arsenicals

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Arsenic trioxide/ Cacodylic acid (Rad-E-Cate®, Arsan®, Phytar®)	• Membrane degradation; inhibition of enzymes containing -SH groups & uncoupling of oxidative phosphorylation.[7] • Taken up by plants like phosphorus.[1]	830[3] (cacodylic acid) • LD^{50} rats: 1350-3200[3]	• Absorption: ingestion or inhalation.[2] • Trivalent compounds more toxic than pentavalent compounds, as less readily excreted by kidneys.[2] • Pentavalent undergo some reduction to trivalent form in gut & body tissues.[8] • Acute & chronic toxicity: gastrointestinal & neurological effects.[2,6] **	• Cacodylic acid toxic to bees[7] (A)[3].	(Cacodylic acid) in soil→ CO_2 + arsenate in aquatic environment→ dimethyl arsine[7] (bacterial degradation). • The arsenic itself is permanently persistent and immobile in soil or sediment.[3]	• Inorganic arsenicals- RPAR issued 2/19/81. • Cacodylic acid-pre RPAR review.	• Burial (turn in)[3,12]. Do not burn- possible dioxin formation.[13]

N.B.: Arsenic trioxide is an insecticide; cacodylic acid is an herbicide.

** Industrial exposure to arsenic implicated in cancer of skin & respiratory tract.[2] Trivalent arsenic found to be embryotoxic and teratogenic in mice.[2]

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PESTICIDES TECHNICAL INFORMATION

Table 10: HERBICIDES

B. Chlorophenoxy Acids

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
2,4-D + salts & esters (Hedonal®, Herbical®, Weed-B-Gon®, Weedar®, Verton-D®, etc)	Complex mechanism of action resembling auxins (plant growth hormones). Affects cell division. Activates phosphate metabolism. Interferes with nucleic acid metabolism.	300-1000[3], 400-500[3], 375[1]	Excreted readily, unchanged, via kidney anion transport system; saturated at ~50 mg/kg. Absorption by ingestion, inhalation & dermal contact. Acute toxicity causes mild to severe irritation to skin, eyes, respiratory and intestinal tracts.[6] Also neurological effects + muscle twitching, fatigue & incoordination. **	Relatively harmless to bees.[7] Toxic to trout & bluegill (LC_{50}=1.2ppm)[3] Dimethylamine salt non-toxic to trout & sunfish Toxic to Carabid & Coccinellid (beetle) predators.[7] Secondary effect of increasing some insect pest problems.	Non-persistent[7] though may last more than 1 yr. in dry areas.5,3 Relatively strongly adsorbed to soil--acids leach moderately; esters don't leach, salts do.[7] Degradation is oxidative & microbial; suppressed in aquatic environments with insufficient dissolved oxygen.[7] Esters are somewhat volatile.[3]	/80 EPA issued equest for uman health data. egulatory ction ppears unlikely.[9]	Incineration (Treatment with alkali); ground surface disposal) 3,12. Do not burn--possible dioxin formation.[13]

** Chronic toxicity - possible peripheral neuropathy after dermal exposure to concentrate.[9,6] May contain dioxins (though not 2,3,7,8 TCDD). Found in one study to be teratogenic in rats.[34] Found in one study to be mutagenic in cultured human cells.[35] Implicated carcinogen in one study.[36] However, suspicions of carcinogenic, mutagenic and teratogenic toxicity are not supported in all other literature. 11,9.

PESTICIDES TECHNICAL INFORMATION

Table 10: HERBICIDES

C. Triazines

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Prometon (e) (Pramitol®)	•Inhibits photosynthesis.[1] •Applied to soil for post-emergence activity.	2980[3] 1750-3000[3] 2745[19]	•Triazines generally low acute toxicity, are not stored in body. •Parent compound & metabolized excreted in urine.[6] •Absorption-ingestion, large doses of triazines have caused anemia and impaired adrenal function in experimental animals.6 •Chronic effects: Certain other triazines found carcinogenic in rats & mice.[38]	•Probably low toxicity in fish LC_{50} = 5-15ppm for other triazines.[3] •Triazines found to form N-nitroso compounds in soil in contact with nitrate. (N-nitroso compounds are potent animal carcinogens).37	•Moderately persistent in soil.[3]		•Turn in; •trash; •incineration (burning); •treatment with alkali.3

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PESTICIDES TECHNICAL INFORMATION

Table 10: HERBICIDES

D. Benzoic Acid Derivatives

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Dichlobenil (Casoron®)	•Seedling growth inhibitor. •Prevents fixation of CO_2 [1]. Rapid action due to rapid permeation & release of C≡N cyanide.[1]	>3160[3,1], 2700-6000[3]	•Acute toxicity: liver (& kidney) damage[8]. Two major metabolites inhibit oxidative phosphorylaction.[8] •Testing for carcinogenicity & mutagenicity inadequate according to our literature review.[8] •No teratology tests performed.	•Low toxicity to fish LC_{50} bluegill=20ppm rainbow trout=22ppm[3]	•Moderately persistent in soil (4 mos) 7,3		•Incineration. (Turn in)[3]. •Burning not appropriate; possible dioxin formation.[13]
Dicamba (Banvel-D®, Banex®)	Probably interferes with nucleic acid metabolism[1]. Auxin-type action.[9]	1040[1], 1100[3], 2900[3]	•Low acute toxicity to mammals[9]; in rats, it is readily excreted via the urine.[9]	•Low toxicity to fish.[3] LC_{50}= 35ppm, sunfish=40ppm[7] •Some persistence in fish used to control aquatic weeds. (Cabel) •Does not bioaccumulate[9]	•Moderately persistent in soil[9]. (3-12 mos)[7] •Very mobile, easily leached.[9] •Degradation microbiol.[9]		•Incineration. (Turn in)[3] •Burning not appropriate-possible dioxin formation.13

PESTICIDES TECHNICAL INFORMATION

Table 10: HERBICIDES
E. Phenol Derivatives

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Pentachloro-phenol PCP (Durotex®, Permite®, Penchlorol®, Dowcide-7®, Penta-Kil®, etc.)	•Destructive to all living cells.[1] •Causes plasmolysis, protein precipitation & desiccation •Used as insecticide, fungicide, & wood preservatives.	•210[3], 280[3], 27-80[1], 36-210[9]. •Dermal: Rats mg/kg 105-350[3]	•Absorbed by ingestion, inhalation, & especially dermal contact.[6] •Acute toxicity uncouples oxidative phosphorylation leading to increased metabolic rate.[2] •Irritates skin, eyes & upper respiratory membranes.[6] •Toxic to liver, kidney & CNS. •Contains dioxins[41] including TCDD. Also contains hexachlorobenzene[9] which is carcinogen in rats[39], and mice[40].	•Toxic to fish,[9,7] and plants.	•Variably persistent: depending on soil type & conditions, 3 wks-5 yrs.[9] •Degradation: microbiol ↔ dechlorination. •Causes rubber to deteriorate.	RPAR issued 10/18/78. Last PD 2/19/81.	•Do not burn. Possible dioxin formation.[12,13]

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PESTICIDES TECHNICAL INFORMATION

Table 10: HERBICIDES

F. Glycene Derivatives

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Glyphosate + salts (Kleen-up®, Roundup®)	Post-emergence herbicide.	4320[1,9]	●Acute toxicity; mild skin & eye irritant.[42] ●May cause stress & elevated metabolic rate in rats.[43] ●Low oral toxicity to humans.[9]	●Low oral toxicity to wildlife and does not bioaccumulate.[9]	●Non-persistent in soil (1mo)[7], >60 days.[42] ● Degradation by microorganisms → CO_2 & phosphonate[7] ●Phosphanate strongly adsorbed onto soil.[7] ●Found to form N-nitrosoglyphosate in soils treated with nitrogen fertilizers.[44] ●Reacts with galvanized and unlined steel to form explosive hydrogen gas-- store & apply only in apparatus made of other materials.[9]		●Turn in (Treat with alkali).[3]

PESTICIDES TECHNICAL INFORMATION

Table 11: FUNGICIDES

A. Dicarboximides

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Captan (Orthocide®)	• Inhibits synthesis of amino compounds & enzymes containing -SH radical.[1] • also bird repellant-bad taste; used on seeds	9000-10,000[3], 8400[3], 9000[1]	• Absorption-acute effects may cause skin irritation.[5] Chronic effects: some structural similarities to Thalidomide. • Found carcinogenic in rats & mice.[45] Found mutagenic in human embryo cells, mouse sperm cells & kangaroo rat cells.[46,47,48] • Found teratogenic in chick embryos & rabbits.[49,50]	• Low toxicity to game birds.[8]	• Moderately persistent in soil.	RPAR issue 8/6/80.	• Treatment with alkali. (burial)[3]
Folpet (Phaltan®, Thiopal®)	See Captan.	>10,000[3,1]		• Low toxicity to game birds.			• Treat with alkali (bury)[3].
B. Benzimidazoles							
Benomyl (Benlate®)	• Induces abnormalities in spore growth due to interference with synthesis of DNA. • Systemic fungicide.	9950[1]	• No information on health effects.	Toxic to earthworms.[8]	• Moderately persistent in soil.[8] • Degradation microbiol.[8]	RPAR 8/3/79	• Bury (Burn)[3].

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PESTICIDES TECHNICAL INFORMATION

Table 11: FUNGICIDES

C. Triazines

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Anilazine (Dyrene®)	No information on this.	2,710 ^{3,1}	•Absorption ingestion. • Structurally different from other triazines-aromatic side group .	•Toxic to fish LC_{50} = 0.015ppm^{3}	•Readily broken down by soil bacteria^{7}. •Soil ½ life - 12 hours in moist conditions 2½ days in dry.^{7}		•Turn in; trash; incineration. (Burning).^{3}

Table 12: RODENTICIDES

A. Coumarins

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Warfarin (D-CON®, WARF®)	•Inhibit prothrombin formation, preventing blood clotting, and cause capillary damage leading to internal bleeding.	186[1], 58-323[3]	•Absorption by ingestion. Same effect on humans as on rats. •Repeated ingestion required before acute symptoms are observed. •No known chronic health effects.	•Toxic in fish[3] (little info available).	•No information on this.		•Incineration. (trash, burial)[3].

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Table 13: MOLLUSCICIDES

A. Aliphatics

Common names (Trade name)	Pesticidal Action	Acute Oral (Dermal) LD_{50} for Rats (mg/kg)	Health Effects	Environmental Effects	Environmental Fate	Regulatory Status	Disposal Recommendations
Metaldehyde (Metason®, Halizan®)	•Attracts & poisons slugs & snails.	600-1000[3], 630[1]	•No information on this.	•Toxic to fish & fresh water snails. Toxic to wildlife, especially birds. Attracts & poisons dogs.	•No information.		•Trash (burn)[3].

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40. Cabral et al., 1977.
41. Cirelli, N.D.
42. John Muir Institute for Environmental Studies, 1981.
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Citations for Tables 9-13, "Pesticides Technical Information" (Continued)

45. National Cancer Institute, 1977b.
46. Legator et al., 1969.
47. Bighami et al., 1977.
48. Fiscor et al., 1977.
49. Verret et al., 1969.
50. McLaughlin et al., 1969.
51. Gill and Lattam, 1972.

SECTION III

PAINT PRODUCTS

A. BACKGROUND INFORMATION

1. Definitions

The "paint products" category refers to a complex group of protective and decorative coating materials, solvents used with these coating materials and surface preservatives. As mentioned in the pesticides section, wood preservatives are pesticides, but are being covered in this section because most people generally think of them as paint products. The actual composition of these different types of paint products will be dealt with in depth later in this section.

Definitions of unfamiliar terms can be found in the Glossary of Terms in Appendix C.

2. Regulatory Framework

No single law or regulation controls the sale and distribution of paint products as FIFRA does for pesticides but a few regulations are of special interest:

- As a result of the need to comply with the Clean Air Act's ambient air standards, there is an accelerated trend toward the adoption of low solvent or solventless coatings.

- The Federal Hazardous Substances Act (FHSA) administered by the Consumer Product Safety Commission (CPSC) spells out the requirements for labeling on hazardous materials, including paint products. Regulations require that labels differentiate between materials that are flammable, extremely flammable, and combustible. The word DANGER must appear on materials that are extremely flammable, corrosive, or highly toxic. For a more in-depth analysis of these labeling requirements, see the review of laws and regulations in the Summary (Part A) of this report series.

- In 1971, Congress passed the Lead-Based Paint Poisoning Prevention Act which restricted the contents of lead in paint to a maximum of one percent. However, concerned citizens thought these restrictions were inadequate and sought a 0.06 percent level (Fritsch, 1978).

- The CPSC cannot regulate how a product is used, but can ban it if the commission finds it presents "unreasonable risk of injury." In 1977 the CPSC banned wall spackling compounds containing asbestos. In 1978 it moved to ban paint and varnish removers containing benzene (McCann, 1979). Benzene has since been voluntarily taken off the market by the manufacturers.

- In March 1972, the EPA issued a notice of intent to cancel all registrations for mercurial pesticides, including their use in paints. In February 1976, after four years of hearings, the agency concluded that the benefits of using mercury in paints and coatings did not outweigh the risks to human beings and the environment and banned their use. Three months later, EPA administrator Russell Train reversed the ban (Fritsch, 1978).

3. Composition of Paint Products

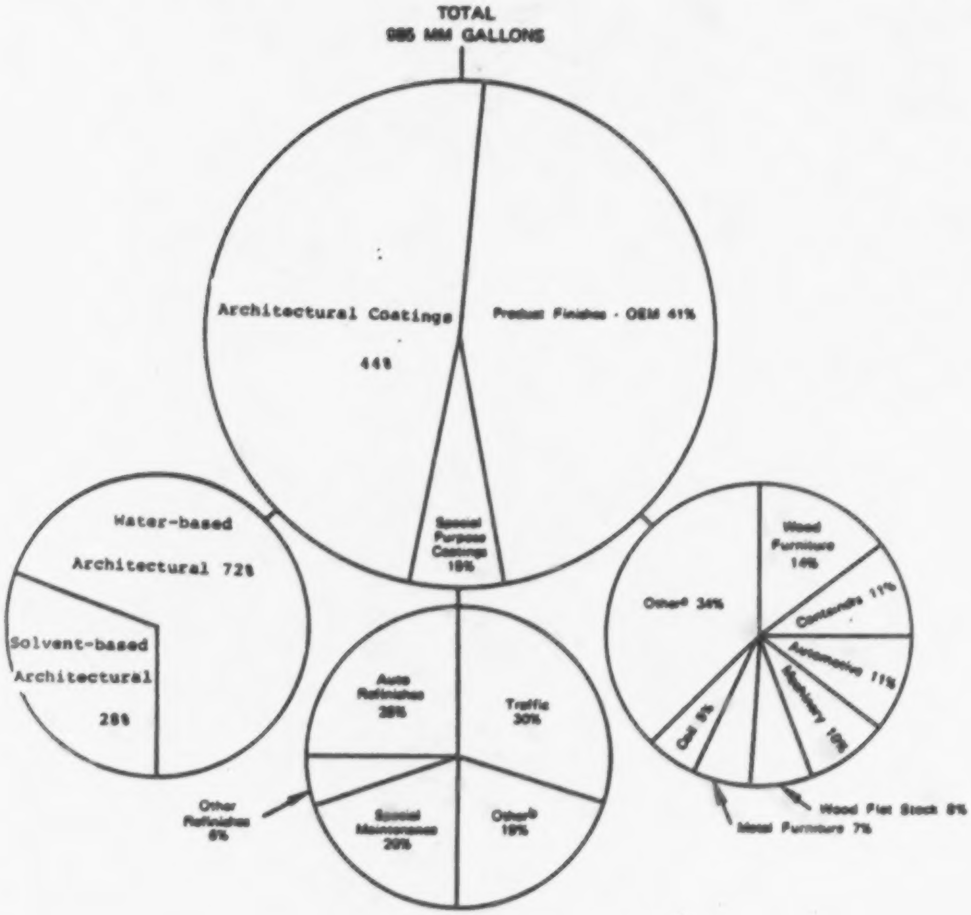
Because the average consumer is unfamiliar with the contents of paints or solvents (e.g., furniture stripper), a crash course on paint products follows. This information was taken substantially from Connolly and Levine (1980).

a. Paints. Paints can be classified as either solvent ("oil")-based or water-based, depending on their primary solvent. Solvent-based paints include enamels, varnishes, lacquers -- either natural lacquers, such as shellacs and gums, or synthetic lacquers, such as cellulosic resins -- primers, stains, seals and sealants, adhesives and specialty coatings. Water-based paints can be latex or watercolors. Different sheens in paint are designated as flat, semi-gloss, or gloss, and can apply to either solvent-based or water-based paints.

Not all paints and coatings are manufactured for use in the home. Figure 2 shows that just 44 percent are used in what are called "architectural coatings," which are defined as "all shelf goods and stock-type coatings that are formulated for normal environmental conditions and general applications on new and existing residential, commercial, institutional and industrial structures" (Connolly and Levine, 1980). They can be broadly classified as either interior or exterior paints. Figure 2 also points out that almost three quarters of all architectural coatings are water-based. Latex paints have steadily replaced solvent-based coatings over the last 20 years due to their ease of application, low odor, easy cleanup, fast drying, and excellent durability.

The average bucket of paint has at least three and usually four major components: 1) film-formers, or resins, the plastic-like material which forms the coating; 2) diluents or solvents, which keep the resins in solution, allow them to be spread, and which then evaporate, leaving the resin behind; 3) pigments, which

Figure 2. PROPORTIONS OF PAINT TYPES MANUFACTURED IN THE U.S.
Percentages are based on 1979 market data.
(Connolly and Levine, 1980.)



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a. Includes appliances, other transportation, marine paper and foil, and other product finishes.

b. Includes roof, bridge, marine shelf goods, metallic, aerosol, and other special purpose coatings.

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provide color and opacity to the paint; and 4) additives, such as surfactants, driers, thickeners, preservatives, anti-skinning agents, anti-foam agents, and others. The exact proportions of these components vary. Many producers have been reducing the total solids content in recent years. Formulations among manufacturers differ, as do formulations within one producer between top-of-the-line and the bottom-of-the-line products. Table 14 gives a general idea of these relative percentages. These four components will be examined at length in the following pages.

Table 14. EXAMPLE OF GENERAL COMPOSITION OF PAINTS
(Connolly and Levine, 1980.)

	Weight Percent		
Contents as shown on label	Bottom of line	Middle of line	Top of line
Resin	7.0	13.5	22.5
Pigment	3.0	12.0	23.5
Additives	18.0	52.0	47.8

Table 15 provides some examples of typical labels found in retail stores, and the percentages of different materials.

- Resins. There are almost as many kinds of resins as there are kinds of paints. Figure 3 shows the various kinds and their relative share of the total resins market. A technical analysis of these can be found in Table 19 at the end of the chapter. Almost half of all resins used are either alkyd or acrylic; other common film-formers used in architectural coatings include vinyl, urethane, cellulosic, styrene-butadiene, natural resins, linseed oil, and plasticizers. Some types of resins are only used in product coatings or other industrial applications.

  Alkyd resins are a type of polyester resin that contains fatty acids of oils as a third component. The so-called oil-free alkyds are classified as "polyester resins." They are the most commonly used resin, their popularity being due to their low cost and great versatility. Their demand is expected to decrease, however, because they are solvent-based. In architectural coatings, alkyd resins are used in interior solvent-based flat, semigloss and gloss paints and exterior house paints and enamels. There is no listing for

Table 15. EXAMPLES OF LABELLING INFORMATION ON PAINTS.
Ingredients obtained from random hardware store selection.

---

1. Latex wall paint:

    - Pigment 32.9%
        - Titanium dioxide Type III 11.6%
        - Silica and silicates 21.3%
        - Tinting material 5%
    - Vehicle 67.1%
        - Acrylic styrene resin 13.9%
        - Glycol ethers and esters 3.4%
        - Additives 1.7%
        - Water 48.1%

2. Exterior house paint:

    - Pigment 38.6%
        - Titanuim dioxide .3%
        - Yellow ferrous oxide 2.5%
        - Ferrous oxide Class II Type A 1.0%
        - Lamp black .3%
        - Silica and silicates 34.5%
        - Tinting material 5%
    - Vehicle 61.4%
        - Acrylic resin 13.3%
        - Tall alkyd & driers 7.1%
        - Glycols, ethers & esters 1.8%
        - Additives 1.4%
        - Water 37.8%

3. Lucite wall and ceiling paint:

    Pigments: Titanuim dioxide, red/yellow iron dioxides
    Silicates
    Vehicle: Acrylic resin
    Ethylene/propylene glycol, glycol ether
    Alkyd interior primer

4. Interior latex flat paint:

    Titanuim dioxide
    Butadiene resin

(continued)

Table 15. EXAMPLES OF LABELLING INFORMATION ON PAINTS. (continued)

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5. All-purpose enamel (oil-base):

    Tall alkyd and driers
    Aliphatic hydrocarbons

6. Semi-gloss enamel:

    Titanium dioxide
    Calcuim carbonate
    Silica/silicates
    Tall soya alkyd
    Driers
    Mineral spirits

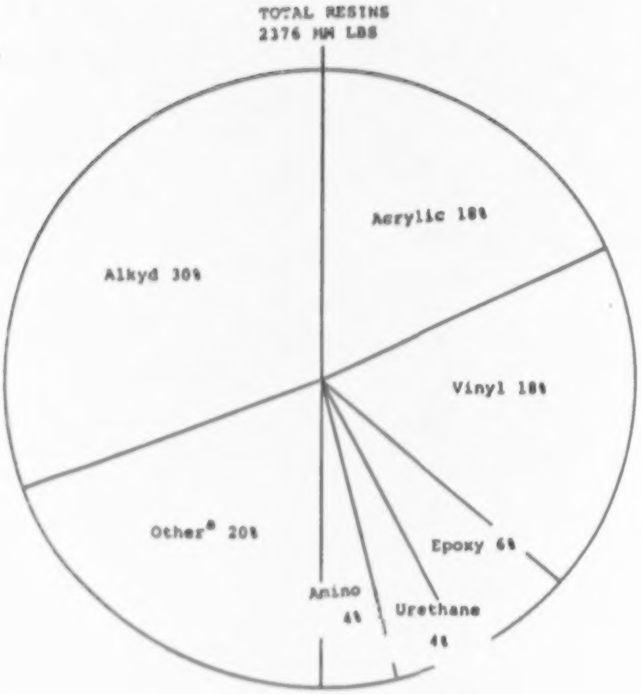
7. Pure aluminum paint:

    Pigment: Alum. Type 2, Class B, Silica
    Vehicle: Petroleum resin
    Linseed oil
    Aliphatic hydrocarbons

8. Rust paint (contains methylene chloride, toluene and petroleum distillates):

    - Non-volatile 19.19%
        - Toluidine Red 3.87%
        - Titanium dioxide .47%
        - Soya alkyd resin 14.85%
    - Volatile 51.86%
        - Aliphatic & Aromatic hydrocarbons 30.7%
        - Halogenated hydrocarbons 19.68%
        - Driers 1.18%
    - Derustite additive 4.25%
        - Soya alkyd resin 1.89%
        - Aliphatic hydrocarbons 1.89%
        - Zinc Chromate Type I .47%
    - Propellant
        - Propane Isobutane 25%

Figure 3. CONSUMPTION OF RESINS BY TYPE IN PAINTS. The percentages are based on 1979 market data. (Conolly and Levine, 1980)



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a. Includes cellulosic, polyester, phenolic, chlorinated rubber, styrenebutadiene, linseed oil, natural resins, plasticizers, and other miscellaneous resins.

alkyd resins in Table 19 as we were not able to determine their exact chemical composition.

Acrylic resins are second in importance. There are a number of kinds of acrylic resins, but the ones used primarily for architectural coatings are the water-based acrylic resins. They are particularly used in exterior latex house paints, interior latex flat paints, and interior and exterior semigloss, gloss and trim paints. A typical acrylic for use in architectural coatings contains methyl acrylate and n-butyl acrylate or ethyl acrylate, depending on flexibility requirements.

Vinyl coating resins are used for their chemical resistance, water resistance, durability, fire-retardant properties, lack of odor or taste and relatively low cost. The type of vinyl most commonly used in architectural coatings is polyvinyl acetate. This is then copolymerized with other monomers such as dibutyl fumarate, dibutyl maleate, ethylene, n-butyl acrylate and 2-ethyl hexyl acrylate.

There are many types of urethane resins; the ones most commonly used in architectural coatings are urethane ester-type resins; also called urethane alkyds or uralkyds. They are used primarily in interior floor varnishes.

The cellulosic resins consumed in coatings consist mainly of nitrocellulose; it is prepared by nitration of cellulose with nitric acid. Cellulosic resins are used in lacquer formulations to produce a finish that is fast-drying and fast-curing at low temperatures. Wood furniture finishes are the largest use of cellulosic resins.

Styrene-butadiene resins used in paints and coatings are copolymers of styrene and butadiene prepared by common emulsion polymerization techniques. They are used for architectural interior latex flat paints, but their consumption has been declining steadily.

Other resins used include polyester, phenolic, amino, epoxy chlorinated rubber, linseed oil, natural resins, plasticizers, and other miscellaneous resins. They were not reviewed because their use is primarily for non-architectural paints (such as industrial product finishes) or because they constitute such a small percentage of the total market.

- Pigments. Pigments added to paints have three main components: 1) Fillers such as talc, clay, silica, and calcium carbonate that provide bulk, inertness and dispersion properties, as well as reduce cost; 2) Colors including metallic pigments such as chromate salts, iron oxide, carbon black, cadmium pigments, titanium dioxide, etc.; and 3) Other substances which provide some other function besides color or hiding, such as corrosion inhibition. These other substances include zinc dust and zinc oxide.

Figure 4 shows these components of pigments and the weight consumption by function and type. A technical analysis of these pigments can be found in Table 20 at the end of the chapter.

(b) Solvents. Solvents or diluents allow the resins in paint to be applied in liquid form. Some solvents are used exclusively in paint production; other solvents are not used in paints at all, but are used separately as thinners or furniture strippers. There is also a great deal of overlap between these two classes of solvents: most are used both in the paints themselves and alone. To make it even more confusing, those solvents that are used "alone" -- for instance, in a can of paintbrush cleaner -- are rarely just one solvent, but are usually a mixture of several solvents. Note as examples the combinations listed in Table 16.

As mentioned previously, water-based architectural paints are used more often than solvent-based; therefore the most common solvent used is water. Figure 5 depicts the percentages of all other solvents used in paints and coatings. A technical analysis of these can be found in Table 21 at the end of the chapter. Understanding the use of solvents and how they relate to each other can be difficult without knowing something about the chemistry of the materials. Appendix A provides A Quick-and-Dirty Organic Chemistry Lesson.

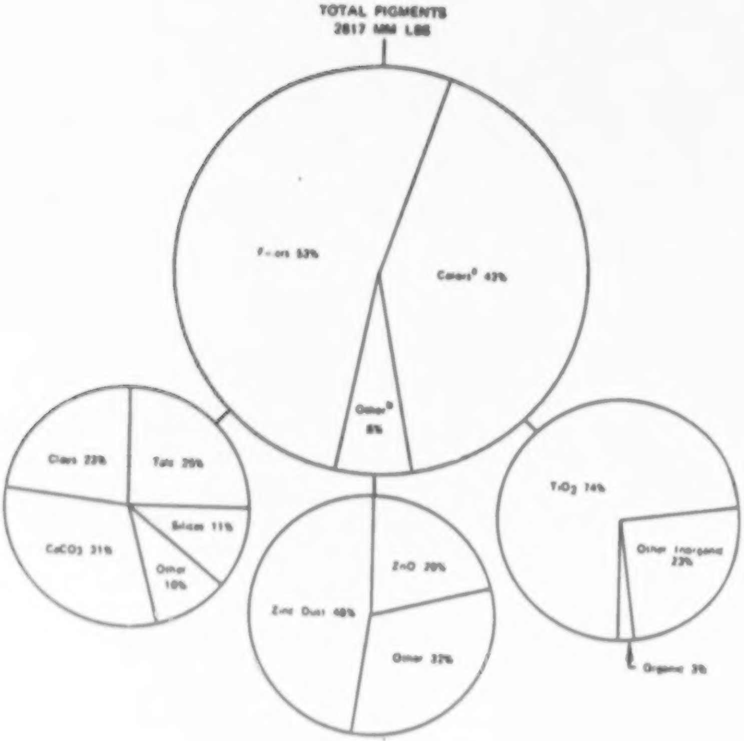
(c) Wood Preservatives. Wood preservatives are pesticides, and therefore contain some active ingredient which will kill or repel pests. They also contain other "inert" ingredients such as solvents which enable the preservative to be applied. Unfortunately, we were unable to determine these "inert" ingredients. Table 17 provides some examples of the types of labels that may be found on wood preservatives. Some commonly used active ingredients in wood preservatives are copper naphthenate, zinc naphthenate, pentachlorophenol, other chlorinated phenols, creosote, naphthenic acid, and magnesium fluorosilicate. A technical analysis of the components of wood preservatives is in Table 22.

B. USE OF PAINT PRODUCTS IN THE HOME

1. Volume Estimates

It has proved to be difficult to obtain usable data on the amount of paint products used and disposed of by households. The clos-

Figure 4. CONSUMPTION OF PIGMENTS BY FUNCTION AND TYPE IN PAINTS.
The percentages are based on 1979 market data.
(Connolly and Levin, 1980.)



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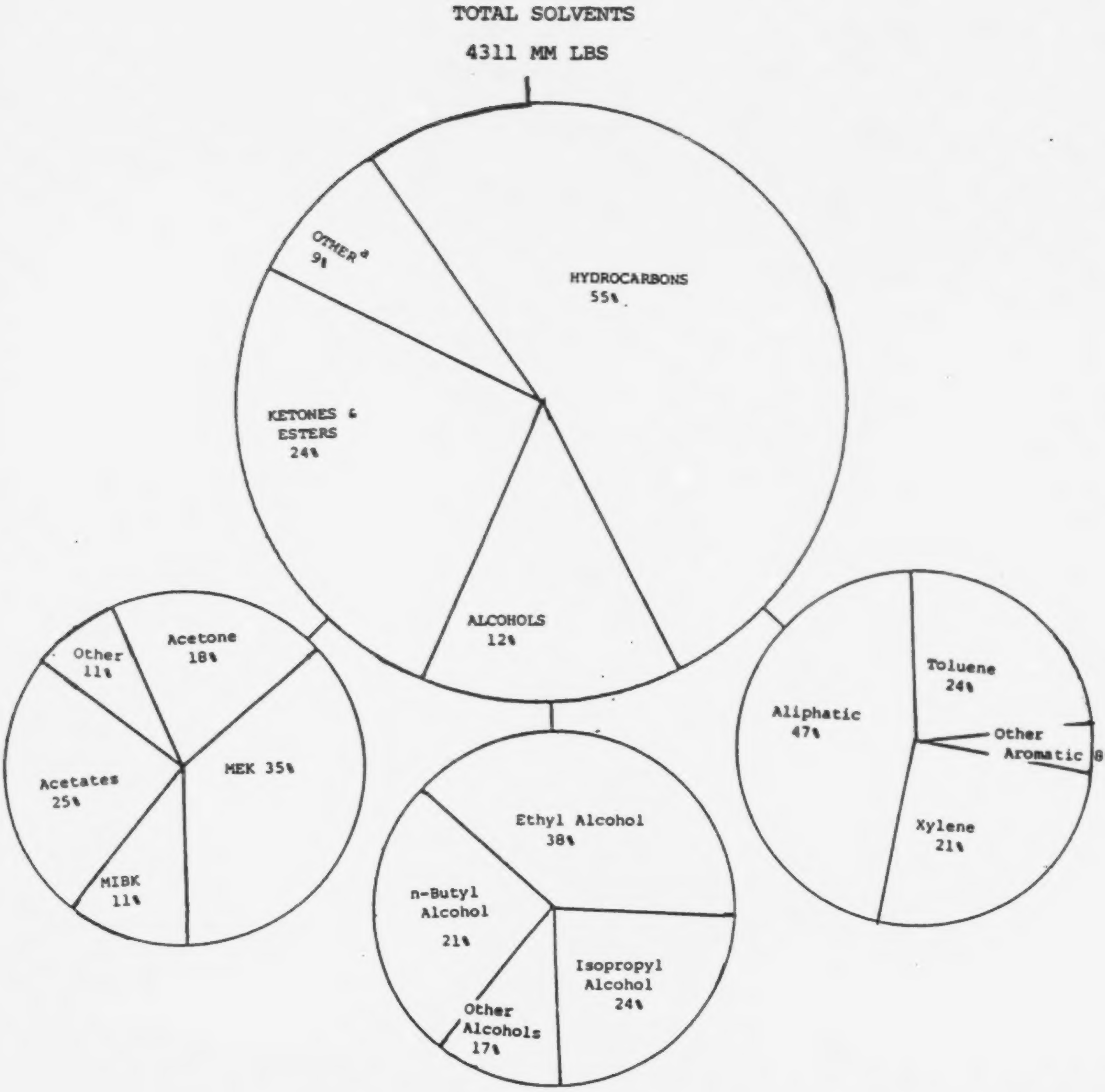
a. Includes metallic pigments (e.g., aluminum) and excludes corrosioninhibiting and other special function colored Pigments.

b. Includes some colored pigments; however, the first order of use of these products is functional (e.g., corrosion inhibition) instead of for color or hiding.

Figure 5. CONSUMPTION OF SOLVENTS BY TYPE IN PAINTS.
Percentages are based on 1979 market data.
(Connolly and Levine, 1980.)



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a. Includes glycols, glycol ethers and ether esters, methylene chloride and other miscellaneous solvents.

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TABLE 16. EXAMPLES OF LABELLING INFORMATION ON SOLVENTS. Ingredients obtained from random hardware store selection.

1. Furniture Stripper - refinisher:

    Contains acetone - no list of contents.

2. Paint and varnish remover:

    Contains methanol, toluol, methylene chloride, acetone, petroleum distillates.

3. Paint remover-wash:

    Can be used as shellac thinner for alcohol burners, marine stoves, chafing dishes or any wick-type alcohol burners. No list of contents.

4. Brush cleaner:

    Contains methylene chloride and methanol.

5. Mineral spirits:

    Contains petroleum distillates. No list of other contents.

6. Artists' spirits of turpentine:

    No list of any other ingredients.

7. Paint, varnish and laquer remover:

    Contains toluene, acetone, methyl alcohol (methanol).

8. Furniture refinisher:

methylene chloride	18%
toluene	18%
acetone	36%
isopropyl alcohol	10%
methyl alcohol	18%

Table 17. EXAMPLES OF LABELLING INFORMATION ON WOOD PRESERVATIVES.
Ingredients obtained from random hardware store selections.

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1. Cuprinol Green Wood Preservative:

Active Ingredient:
Copper naphthenate 20% minimum
(equivalent to metallic copper 2%)
Inert ingredients 80% maximum

2. Clear Wood Preservative:

Contains petroleum distillates
Active ingredient: Zinc naphthenate
(equivalent to metallic zinc 2%)
No list of other ingredients

3. Woodlife Wood Preservative:

Contains pentachlorophenol and petroleum spirits
Pentachlorophenol 4.3%*
Other chlorphenols .5%
Inert 95.2%

*Equivalent to 5.0% technical grade in accordance with Federal Specification. TT-W-570.

est that we could find were the figures collected by the National Paint and Coatings Association on national industry-wide consumption of these products. We have presented these for the individual chemicals in Tables 19 through 22 at the end of this chapter. Some things to note about these figures: Especially in the case of solvents, these chemicals are used by other industries besides paints and coatings. However, the figure given is *not* total production or consumption of this chemical -- it is consumption in the paints and coatings industry *only*. As mentioned in the previous section, solvents are problematical because they can be used either in the paint or "alone." It is unclear whether the consumption figures given for solvents include their use in 100 percent formulations or whether it just takes their use in paints into account. The consumption figures in the tables do *not*, however, refer to *household* uses of these paint chemicals, *but* to *all* uses and consumptions; thus they do not accurately reflect the volumes which pose a potential for disposal by homeowners.

On a local level, estimates can be made concerning volumes of paint products used, but we have not been able to discover any specific data. According to informed estimates (Nolan, personal communication) about seven to eight million gallons of paint are used in the Metropolitan Seattle area each year. This works out to about three gallons per year for every man, woman, and child in the population and includes commercial and trade products. If we anticipate that only 50 percent of this is household use, we can still figure on approximately one-and-one-half gallons per person per year. Other estimates vary considerably from this. One source (Gurnham *et al.*, 1979) stated that the average household (2.525 persons) consumed only 2.09 ounces per year of paint and 5.2 ounces per year of paint thinner. While most of this paint will be used for its intended purpose, some excess will be disposed of in the drain or trash.

Unlike other household products, paint products may only be wasted into the disposal system three to four times per year from a single home (Hathaway, 1980). Although infrequent, the volume wasted could be high and therefore a cause for concern. As much as two to three liters of paint and/or solvents may be disposed of down the drain during one day's painting session (Hathaway, 1980). Preservatives probably do not enter the wastewater on a regular basis. Instead, when disposal does occur, it is in large volumes and in a highly concentrated form, and thereby poses a greater potential for environmental harm.

2. Routes Into the Environment

The manner in which paint products are disposed often depends on their physical state. Liquid paint products are usually discarded into domestic wastewater which is then "treated" by either an on-site (septic tank/drainfield) system or a municipal treatment plant system. Solid paint products are often discarded with the refuse going to a local landfill, which may or may not be secured against groundwater contamination.

Many solvents are discharged to home septic tanks, where evaporation is inhibited and anaerobic conditions play a major role. Studies of such anaerobic conditions have reported the inhibition of anaerobic digestion of sewage sludge by various chlorinated hydrocarbons. If waste paints and solvents are discharged to the regional sewerage system, they will most likely be diluted to the point where their contributions and impacts to the treatment system or the environment are not able to be distinguished from the total flows from industrial and commercial activities as well. A spill or dumping into a storm sewer would have a much greater potential for environmental damage due to its direct impact on local surface waters.

C. ENVIRONMENTAL IMPACT

Most of the information concerning the environmental effect of the chemicals used in paint products has been put in Tables 19 through 22 at the end of the chapter.

1. Paints

Not much is known about the activity of paint products in the landfills or sewerage system. We can only make some educated guesses concerning which of these chemicals and products have the greatest potential for environmental harm.

Paints as a class appear to pose relatively little potential for damage. The paint products industry has had many presures on it to make its products as safe as possible. As a result, the metal pigments such as lead and cadmium which previously were used extensively have now been replaced by less toxic alternatives. This is of benefit not only for human health reasons, but because it lessens the chance that these persistent chemicals could contaminate the soil or water. Of course, some paints still do contain heavy metals such as cobalt, mercury, lead (less than 0.06 percent), and vanadium; it appears, however, that they are not in the most common pigments. Another exception to this general rule of low heavy metal content in paints is in art supplies; they continue to contain significant levels of heavy metals (see McCann, 1979). The other components of paints -- resins, fillers, synthetic pigments -- appear to be very inert and harmless (for specifics, see Tables 19 and 20). Furthermore, paints do not tend to be disposed of in a manner which presents an environmental threat. They are usually disposed of in the trash, usually in their original containers with tight-fitting lids, or after they have already dried out.

2. Solvents

Solvents are a different matter. Although not related directly to the disposal issue, their hazard to human health deserves mention. All solvents are toxic to some degree or another, in that they all have the potential for damage to skin, eyes, respiratory tract, nervous system and internal organs. Some solvents are considered less hazardous than others: alcohols, ketones, esters and petroleum distillates are only moderately toxic. This means that it would take more of these solvents to achieve a toxic effect than for the most toxic solvents. These latter include the aromatic and chlorinated hydrocarbons such as benzene, toluene, xylene, methylene chloride, trichlorobenzene, and 1,1,1-trichloroethane. These tend to pose chronic health hazards in addition to the known acute toxicity. Furthermore, the aromatics and chlorinated solvents can be absorbed through the skin, and thus the user is more likely to be harmfully exposed to this class of solvents than for those in which ingestion is the means for exposure and effect. Even though some of these solvents have a potential for irreversible damage and/or are suspected carcinogens, there is surprisingly little common knowledge of the hazards associated with use. Many of the solvents are toxic to aquatic life in low concentrations. Solvents also pose an environmental hazard in the atmosphere, where they can enhance smog conditions in urban areas. Los Angeles County has measured the amounts of volatile solvent chemicals in the air and found that reducing the use of these solvents would significantly reduce the levels of smog in the area (Fritsch, 1978); the county has banned some solvents and enacted legislation to regulate the degree of volatility in paints. Although local air pollution authorities do not believe these "fugitive" emissions contribute significantly to problems in Seattle (Nolan, personal communication), Seattle does have an ever-increasing smog problem.

Many of the solvents, particularly the halogenated (and especially the chlorinated) hydrocarbons, are also quite persistent in the environment, resisting ordinary breakdown to less harmful components. This is particularly the case if they are not allowed to volatilize by being trapped in the groundwater (for instance, from septic tank leachate).

3. Wood Preservatives

Wood preservatives likewise can be considered to present a much greater risk of environmental contamination than paints and perhaps more than solvents. They tend to be more carefully handled and disposed of than solvents; certainly the explicit warnings on the wood preservatives labels contribute to this caution. Preservatives are some of the most hazardous products likely to be found in a household, both in terms of the potential for acute and chronic human toxicity, and for the danger that they can do in the environment. The constituents of greatest concern are the chlorinated phenols, which are highly toxic to man, mammals and aquatic life. Fish and other aquatic organisms show a wide range of sensitivity; however, acute toxicity values are generally at low levels. Acute toxicity also appears to increase with chlorination.

The most commonly used and powerful of the chlorinated phenols is pentachlorophenol (PCP). Because of PCP's primary uses, air and land are generally the release media. Relatively little enters surface or groundwaters. Vaporized PCP is reported to have an airborne duration of over a month, finally either decomposing due to photolysis, or being washed out by rain. Once introduced into the soil, PCP firmly attaches itself to fine organic particles, so very little migration occurs, except following larger spills. It is highly resistant to biodegradation and can be detected in soils and sediments for over a year after exposure.

Pentachlorophenol is only slightly soluble in water and once in the water usually does not volatilize. It is generally removed from the water column by adsorption to fine mineral and organic particles either in suspension or in the sediments. Photodegradation can occur in clear, shallow waters. Potential sources of water entry are: rainout and dryfall of vaporized PCP (approximately 350 metric tons per year enter the atmosphere), industrial spills, transportation spills, application near water, and leaching from treated wood.

PCP has been found to be toxic to most organisms (some aquatic plants and mollusks show acute effects at less than 10 ppb). In addition, some commercial preparations were found to contain impurities even more toxic, such as chlorinated dioxins. PCP can accumulate in fish and mollusks to over 100 times ambient concentrations. It has been found to be moderately toxic to mammalian species following acute ingestion or dermal exposure.

Not as much is known about other wood preservatives. The metal-based preservatives, such as copper or zinc naphthenate, tend to be absorbed into the wood, the solvent evaporates, and the metals stay in the wood. These heavy metals are much more persistent in the environment than the phenolic compounds, which will eventually biodegrade.

It should be repeated that all wood preservatives are classified as pesticides. Information on FIFRA and general pesticide characteristics are found in section II of this report.

Table 18. PAINT PRODUCTS: CHEMICALS REVIEWED.
The following chemical ingredients are
reviewed in the Product Technical
Information Tables 19-22

I. RESINS — Table 19
(Alkyd - none reviewed)

- A. Acrylic
    1. n-butyl acrylate
    2. ethyl acrylate
    3. methyl acrylate
- B. Vinyl (examples)
    1. ethylene
    2. 2- ethyl hexyl acrylate
    3. vinyl acetate
- C. Urethane
    1. urethane alkyds
- D. Cellulosic
    1. nitrocellulose
- E. Styrene - butadiene
    1. styrene
    2. butadiene

II. PIGMENTS — Table 20

- A. Fillers
    1. calcium carbonate
    2. silica
    3. silicates (talc and clay)
- B. Colors (examples)
    1. carbon black
    2. chromate salts
    3. cuprous oxide
    4. iron oxide
    5. titanium dioxide
    6. zinc oxide

III. SOLVENTS — Table 21

- A. Alcohols
    1. n-butyl alcohol
    2. ethyl alcohol
    3. isopropyl alcohol

(continued)

Table 18. PAINT PRODUCTS: CHEMICALS REVIEWED.
(continued)

- B. Aliphatic and Aromatic Hydrocarbons (examples)
  - 1. mineral spirits*
  - 2. petroleum ether*
  - 3. toluene
  - 4. VM + P Naphtha*
  - 5. xylene
- C. Ketones and Esters (examples)
  - 1. acetone
  - 2. butyl acetate
  - 3. ethyl acetate
  - 4. methyl ethyl ketone
  - 5. methyl isobutyl ketone
- D. Other Solvents
  - 1. cresols
  - 2. ethylene glycol
  - 3. ethylene glycol monobutyl ether
  - 4. methylene chloride
  - 5. perchloroethylene*
  - 6. propylene glycol
  - 7. 1,1,1 trichloroethane*
  - 8. turpentine

IV. WOOD PRESERVATIVES — Table 22

1. chlorinated phenols
2. copper naphthenate
3. creosote
4. magnesium fluorosilicate
5. naphthenic acid
6. pentachlorophenol
7. zinc naphthenate

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*do not tend to be found in paints, but rather are used alone, or in mixtures of solvents, or in non-paint products

D. INFORMATION ON PAINT PRODUCT CHEMICALS

1. Study Methods

The paint products that were reviewed are listed in Table 18. In attempting to narrow the focus of this study, we have excluded some products which technically could be considered paint products, such as adhesives, putty, and so on. We also have not examined those paint products classified as industrial or commercial varieties ("non-architectural"), even though these sometimes contain pigments of very toxic metals, or higher concentrations of hazardous solvents. These industrial and commercial paint products are also used in very large volumes, and could pose a distinct threat to environmental quality. Nevertheless, they have been excluded in this household review. We also did not attempt to delve into the hazardous nature of art or crafts materials, which include not only paint and solvent chemicals, but also irritating and poisonous gases, mineral dusts from stone carving and ceramics, biological dusts, dyes and organic pigments used in silk-screening and fabric arts, metal fumes from jewelry-making, and so on. Persons interested in these hazards are directed to Michael McCann's (1979) definitive book, Artist Beware. Finally, we have included wood preservatives in the category of paint products, even though they are classified as pesticides (by law). This was done because of common perceptions of wood preservatives as another kind of paint.

Technical information on the health and environmental effects of residential paint products has been compiled in Tables 19 through 22. Users of these tables should be aware of several warnings:

- Many of the toxic exposure limits (e.g., PEL -- permissible exposure limit for air) are based on occupational exposure and are set low enough so that nearly constant exposure will not result in significant harm to the worker. Exposure in the home would tend to be more sporadic under most conditions.

- The information provided on the health and environmental effects of these paint product chemicals is for those chemicals alone. It does not take into account the dilution factor which occurs when the chemical is in a mixture with others. On the other hand, the values also do not reflect the synergistic effects which are possible when chemicals are mixed together.

- There are many gaps in the information which is available on these products and their components. A lack of information could mean either 1) that the chemical is not hazardous and therefore we could not find any reference to it in our reference materials, or 2) the chemical may be hazardous, but no testing has been done to assess it. Therefore, the presence or absence of information on a chemical is not meaningful in the tables.

As with all the products' technical information sections, three "keys" will help the reader to decipher the information:

- Numbers in superscript or parentheses refer to the source from which the information was taken. A key to these sources can be found in the Citations listings at the end of the tables on page 101. Complete listings of these citations are found in the References section at the end of this report (page 179).

- Abbreviations and unfamiliar terms can (usually) be found in Appendix C: Glossary of Terms and List of Abbreviations on pages 213 and 221, respectively.

- The chemistry of these substances, particularly for solvents, can be confusing. We suggest reading Appendix A (A Quick-and-Dirt Organic Chemistry Lesson) on page 190 if you are unfamiliar with the classes and groupings of these chemicals. Toxicity ratings and determinations are explained at length in Appendix B, page 201.

PAINT PRODUCTS TECHNICAL INFORMATION

Table 19: RESINS

A. Acrylic

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Ethyl acrylate	•Synonyms: ethyl ester acrylic acid, ethyl propenoate •Used in production of water based acrylic resins for paints & coatings (13)	Water-based •all acrylic paints & coatings - 275 mp (13)	•Irritant: eye rat 1204 ppm/14 hrs skin rabbit - 500 mg mild irritant (12) •inhalation human TC_{LO}: 50 ppm (12) oral rat LD_{50}: 1020 mg/kg (12) •PEL (air): 25 ppm (100 mg/m^3) (skin) (3) •ACGIH has set TWA 5ppm (20 mg/m^3) •STEL - 25 ppm (3) •IDLH - 2000 ppm (3)	•Currently tested by NCl for carcinogenicity by standard bioassay protocol 12/78 (12) •irritation of eyes, skin & respiratory system (3) •exposure to excessive vapor may cause drowsiness accompanied by nausea, headache or extreme irritation of respiratory tract (5) •liquid causes smarting of skin & first-degree burns on short exposure (5)	•Flammable •incompatible with oxidizers, peroxides, polymerizers, strong alkalies & moisture (3) •no criteria in water •TL_m 96: 1000-100 ppm (12) •aquatic toxicity - TL_m: 12 ppm/24 hr/brine shrimp (5) fouling to shoreline (5)	•Hazardous waste (EPA) •Disposal recommendations: incineration (3)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 19: RESINS

A. Acrylic (continued)

	●Source of chemical ●Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Methyl methacrylate	●Synonyms: Lucite, poly-methyl methacrylate.	●Approximately 275 million lbs/yr. (13)	●PEL (air): 100 ppm (410 mg/m^3) (3) ●STEL: 125 ppm (510 mg/m^3) (3) ●IDLH: 4,000 ppm (3) ●implant mouse TD_{LO}: 1300 mg/kg toxic effect: carcinogen (12)	●Hazardous substance (EPA) ●irritating to eyes, nose & throat. May cause dermatitis & narcosis. (3)	●Flammable ●incompatible w/nitrates, oxidizers, peroxides, polymerizers, strong alkalis and moisture (3) ●permissible concentration in water: no adverse effect level in drinking water 0.7 mg/l (NAS) (3)	●Hazardous waste (EPA) ●Disposal recommendations: incineration.
n-Butyl acrylate	●Synonyms: butyl ester 2-propenoic acid; butyl ester acrylic acid ●found in acrylic resins of water-based acrylic paints.	●All water-based acrylic paints: 275 mp (13)	●Irritant: skin rabbit 10 mg/24 hr. mild irritant (12) ●oral rat LD_{50}: 3730 mg/kg (12) ●inhalation rat LC_{LO}: 1000 ppm 4 hr. (12) ●No PEL, but ACGIH recommends TWA 10ppm (55 mg/m^3) (3)	●Moderately irritating to skin, may produce tissue degeneration in eye if unwashed (3) ●exposure of rats at 1,000 ppm for 4 hrs proved lethal to 5 of 6 rats exposed; however, rats survived 30 min. exposure at 7000ppm (3)	●Flammable, combustible, floats on water ●effect of low concentration on aquatic life unknwon; fouling to shoreline (5) ●no criteria ●aquatic toxicity TL_m 96: 1000-100 ppm (12)	●Most water-based acrylic paints used in exterior and interior latex, exterior semi-gloss, gloss & trim paints. (13)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 19: RESINS

B. Vinyl

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Vinyl acetate	•Copolymerized with didutyl fumarate, dibutyl maleate, ethylene, n-butyl acrylate and 2-ethyl hexyl acrylate to produce vinyl resins	•All water based (mostly vinyl acetate) 334 mp (13)	•Irritant skin rabbit: 10mg/24hrs (12) •Oral rat LD_{50}: 2920 mg/kg (12) •inhalation rat LC_{LO}: 4000 ppm for 4 hrs (12) •TLV: 10 ppm (12) •NIOSH recommends 4ppm (15 mg/m^3) for 15 min. (ceiling) (7) •ACGIH set TWA 10 ppm (30 mg/m^3), tentative STEL 20 ppm (60 mg/m^3) (7)	•Hazardous substance (EPA) •vinyl acetate vapors at concentrations below 250 mg/m^3 is primary irritant to upper respiratory tract and eyes. No known residual systemic effects (7).	•Aquatic toxicity: TL_m 96: 100-10ppm (12) •flammable liquid (12) •no criteria in water.	•Low molecular weight vinyl acetate is used as a chewing gum base (7) Disposal recommendations: Incineration.

PAINT PRODUCTS TECHNICAL INFORMATION

Table 19: RESINS

B. Vinyl (continued)

	●Source of chemical ●Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
2-ethyl hexyl acrylate	●Used as copolymer in production of vinyl acetate for resin in paints (13) called vinyl acrylics	●All water-based (vinyl acetate) resins: 334 mp (13)	●Skin rabbit - 500 mg-open Mild irritant (12) ●skin rabbit 10 mg/24 hr severe irritant (12) ●oral rat LD_{50}: 5660 mg/kg (12) ●skin rabbit LD_{50}: 1600 mg/kg (12)	●Vapors non-irritating to eyes and throat (5). ●may cause smarting & reddening of skin if in contact with skin or clothes (5) ●inhalation of vapor causes drowsiness & convulsions. Liquid causes irritation of eyes. Ingestion produces same symptoms as inhalation. (5).	●Colorless liquid, sharp odor. ●combustible, containers may explode in fire ●aquatic toxicity: TL_m 96: 1000-100ppm (12) ●aquatic toxicity: TL_m 72 ppm/24 hr/brine shrimp (5) effect of low concentrations on aquatic life unknown--fouling to shoreline (5)	
Ethylene	●Synonyms: acetene, ethene, olefiant gas. ●Copolymerized with vinyl acetate in production of vinyl resins for paints.	●All water-based (poly-vinyl acetate) resins: 334 million pounds (13)	●Inhalation mouse - LC_{50}: 95 pph (12) ●inhalation mammal LC_{LO}: 950000 ppm/ 5 min. (12)	●Selected by NCl for carcinogenesis bioassay 12/78 (12) ●vapor not irritating to eyes, nose or throat, if inhaled, will cause headache dizziness, loss of consciousness (5) ●liquid will cause frost-bite; do not rub (5)	●Aquatic toxicity: TL_m 96: 1000-100 ppm (12) ●flammable ●floats and boils on water. Flammable visible vapor cloud is produced (5) ●aquatic toxicity: 22ppm/1 hr./sunfish/ killed/freshwater (5).	

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 19: RESINS

C. Urethane

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Urethane alkyds	•Synonyms: ethyl ester carbamic acid, ethyl carbamate •Used as resin in paints and (primarily) varnishes	Urethane alkyds: 27 mp	•Carcinogenic determination: animal positive (ARC) (12) •oral rat: 2000 mg/kg toxic effect: cancer (12) •subcutaneous rat: TL_{LO}: 800 mg/kg toxic effect: cancer (12) •inhalation mouse TC_{LO}: 138 ppm toxic effect: neoplasmic (12) •intraperitoneal rat: TL_{LO}: 900 mg/kg toxic effect: teratogenic (12)	Unknown	•Pollutants resulting from combustion: hydrogen cyanide, carbon monoxide (15)	

D. Cellulosic

Nitrocellulose	•Synonyms: cellulose tetranitrate, guncotton •Used in production of resins for paints	•Nitrocellulose is major cellulosic resin used • 47 mp. (13)	Unknown	Unknown	•Flammable; environmental effects unknown	

PAINT PRODUCTS TECHNICAL INFORMATION

Table 19: RESINS

E. Styrene-butadiene

	●Source of chemical ●Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Styrene	●Used in interior latex flat paints	●For styrene butadiene paints: 18 million pounds/yr. (13)	●PEL (air): 100 ppm TWA with ceiling 200 ppm with acceptable peak of 600 ppm for 5 min (1) ●good warning properties (1) ●IDLH: 5000 ppm (3)	●Short term exposure: irritating to eyes, nose, throat & skin. High concentrations can cause drowiness & death (1). ●long-term exposure contact may cause skin rash (1)	●Incompatible w/oxidizing agents & catalysts, such as peroxides, acids or aluminum chloride (1) ●toxic gases & vapors may be released in fire (1) ●will corrode copper & dissolve rubber (1) ●styrene is stabilized by a polymerization inhibitor. If this is not present in adequate concentrations, styrene can polymerize and explode. (1)	Disposal recommendations: 1. Absorb in vermiculite, etc., and dispose in secure landfill. (1) 2. atomize in suitable combustion chamber (1)
Butadiene	●Used in interior latex flat paints	●For styrene-butadiene paints: 18 million pounds/yr (13)	●PEL (air): 1000 ppm TWA (2000 mg/m^3) (1) Odor threshold 4 mg/m^3 (5) Good warning properties (1)	●Overexposure causes irritation of eyes, nose, & throat, drowsiness & light-headedness--exposure to very high concentrations can cause unconsciousness & death (1) ●Prolonged skin contact can cause irritation, frostbite (1)	●Flammable gas ●incompatible with strong oxidizers, copper or copper alloys (explosions) (1) ●toxic gases and vapors may be released in fire (1)	Disposal recommendations: liquid-atomize in combustion chamber. Gas - burn in safe location (1)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 20: PIGMENTS

A. Fillers

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Silicates	•Silicates such as talc & clay contain silica bound to metals & water (6). •Synonym for talc: magnesium silicate (commercial mixtures often contain other minerals) (13) •Synonyms for clay: kaolin, bentonite, fuller's earth, ball clay. •Used as filler in paint pigments.	Talc: estimate: 350 mp (13) Clay: 320 mp	Talc: •TLV: 20 mppcf (12) •PEL (air): 20 mppcf TWA (12)	•Silicates by themselves do not cause silicosis (chronic illness caused by inhalation). In some cases, exposure to large amounts of silicates can cause diffuse or mild scarring of lungs (6) •no acute toxicity by ingestion--slightly by inhalation (9)	•Fine powder •Unknown environmental effects (probably none)	•Used for properties of inertness, flatting, dispersibility and low cost (13) •use of Talc expected to decline due to OSHA regulations.

PAINT PRODUCTS TECHNICAL INFORMATION

Table 20: PIGMENTS
A. Fillers (continued)

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Silica	•Used as filler in paint pigments- may be natural or synthetic; paint industry uses primarily natural amorphous silica, diatomaceous earth, and synthetic amorphous silica (13)	162 mp (13)	•Oral rat LD_{50}: 3160 mg/kg (12) intraperitoneal mouse LD_{LO}: 40 mg/kg (12) •PEL (air): 80 mg/m^3 TWA (12) • ACGIH recommend TLV 6 mg/m^3 for total amorphous silica dust, and 3 mg/m^3 for respirable dust (3)	•pneumonconiosis (3) when inhaled •chemically and biologically inert when ingested (9)	•Incompatible w/fluorine, oxygen difluoride, chlorine trifluoride (3) •no criteria for water	•Disposal recommendations: sanitary landfill (3)
Calcium carbonate	•Synonyms: limestone, chalk, dolomite, marble •Used as filler in pigments--can be natural or synthetic; natural most commonly used in house paints (13)	natural: $CaCO_3$: 410 mp (13)	•Oral human LD_{LO}: 5000 mg/kg (12) TLV: 10 mg/m^3 (12)	•An excellent antacid and good antidote for oxalic acid (9) •no oral toxicity per se except for gastric irritation (9) •injected subcutaneously or intramuscularly, are intensely irritating; may cause alkalosis with continued use (9)	•Aquatic toxicity: TL_m 96: > 1,000 ppm (12)	•Used as extender; has high brightness, inertness, dispersibility and low cost (13)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 20: PIGMENTS

B. Colors

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Carbon Black	•used in all pigmented paints	20 million pounds/yr	•PEL (air): 3.5 mg/m^3 TWA tentative STEL: 7 mg/m^3 (3) • intravenous-mouse LD_{50}: 440 mg/kg (12)	•no harmful effects expected (3)	•incompatible w/strong oxidizers, such as chromates, bromates, nitrates (3)	
Chrome	•used in variety of forms in paints--most common is lead chromate salts (e.g., chrome yellow, molybdate orange) and zinc chromates, also chromium oxides, chrome greens, strontium chromate, etc) •found in some exterior paints, primers & special paints (13)	80 million pounds/yr (13)	chrome dust •PEL (air): 1 mg/m^3 (1) •NIOSH exposure for carcinogens: .001 mg/m^3 and regulate as occupational carcinogens (1) non-carcinogenic forms: 0.025 mg/m^3 with ceiling .05 mg/m^3 for 15 minutes (1)	•chrome metal: some forms cause higher risk of respiratory cancer--other forms don't •exposures associated w/ toxic effects are usually mixed exposures (several hexavalent chromium forms) (1)	•flammable (1) •incompatible w/strong oxidizers--may cause fires & explosions	•lead-chromate based paints prohibited in architectural paints (home use) •disposal recommendations: in sealed containers in secure landfill

PAINT PRODUCTS TECHNICAL INFORMATION

Table 20: PIGMENTS

B. Colors (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Cuprous oxide	•synonyms: copper oxide, cuprocide, yellow cuprocide, etc. •used mostly in marine anti-fouling paints	8 million pounds/yr	•high toxicity via oral (2) •ratings/standards for copper mists and dusts only- -PEL: 1 mg/m^3 -oral rat LD_{50}: 940 mg/kg (12)	•short term exposure (mists,dusts): chills, similar to common cold (1) •long-term exposure: skin irritation, discoloration of skin & hair (1) •copper oxide produces local irritant effects when in contact w/eye (1)	•incompatible w/acetylene gas (result in copper acetylides) which are very sensitive to shock Also, incompatible w/ magnesium (result in flammable hydrogen gas) (1) •copper doesn't accumulate, not highly toxic in environment	disposal recommendations: in sealed containers in secure landfill (1)
Iron oxide	•used in exterior house paints, wood filters, stains, other uses •can be either natural or synthetic origin	•synthetic: 74 million pounds/yr •natural: 47 million pounds/yr total: 121	• Iron oxide fumes: •PEL (air): 10 mg/m^3 •ACGIH recommends • TLV 5 mg/m^3 (1) subcutaneous rat TD_{LO}: 135 mg/kg (12)	•repeated exposure over period of years may cause changes in lungs, but not fibrosis (1) •carcinogenic determination: indefinite (12)	•contact of fumes w/ calcium hypochlorite may cause explosives (1) •aquatic toxicity: TL_m 96: > 1,000 ppm	ventilate (1)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 20: PIGMENTS

B. Colors (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Titanium dioxide	•used as opacifier (whitener) in paint	830 million pounds/yr	•fumes PEL (air): 15 mg/m^3 15 mg/m^3 TWA (12) •irritant: skin human: 300µg mild irritant (10) •toxic dose: intramuscular rat-TD_{LO}: 300 mg/kg (12)	•considered a "nuisance dust", or mild pulmonary irritant (slight changes in lungs may appear) •lesions appear to be result of dust, not tita dioxide (1)	•physiologically inert No water criteria, but EPA suggests permissable ambient goal 83 ug/l (1) •aquatic toxicity rating TL_m 96: >1,000 ppm (12)	Disposal recommendations: may be disposed in a secure landfill (1) (3)
Zinc oxide	•used in paints: (a) 99% of lead free paints contain ZnO_2. (2) Also found in lead-containing paints (which have 12-50% lead sulfate).	30 million pounds/yr	Zinc Oxide fumes: PEL (air) 5 mg/m^3 TWA -NIOSH recommends: 5 mg/m^3 TWA w/ceiling of 15 mg/m^3 for 15 min (1) •irritant: skin rabbit: 500 mg/moderate (12) •toxic dose: -oral human: LD_{LO}: 500 mg/kg	•short-term: metal fume fever, which is flu-like illness high levels of exposure may cause metallic taste in mouth, dryness of throat & coughing (1) •long-term: none known (1) •toxicity variable, but generally low to humans (2)	•may react violently with chlorinated rubber (1) •acutely toxic to freshwater organisms at concentrations as low as 90 ug/l chronically toxic at concentrations as low as 25-51 ug/l (4) •ambient water criteria (AWC) 5mg/l (4)	Ventilate

PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

A. Alcohols

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
n-Butyl Alcohol	• synonyms: 1-butanol; propylcarbinol; n-butanol; NBA; etc. • produced by oxo process (13) • found in paints, organic solvents, paint brush cleaners, paint/varnish removers, etc.	Estimate 110 million gals/yr 21% of alcohols produced are n-butyl alcohol (13)	• moderate to high via oral moderate via skin (2) • inhalation: -PEL (air): 100 ppm TWA (300 mg/m^3) (1) -ACGIH recommends TLV of 50 ppm (1) -IDLH - 8,000ppm (3) • toxic dose: -oral rat: LD_{50}: 790 mg/kg (12) -oral human LD_{LO}: 500 mg/kg (12) -skin rabbit LD_{50}: 4200 mg/kg (12) inhalation human: TC_{LO}: 25 ppm (12)	• irritant to eyes, nose, throat (2) • vapor has narcotic effect on animals at concentrations 6000-8000ppm (1) • mild narcotic effects (headache, dizziness) reported in humans (1) • long term exposure: dermititis (2) • no chronic systemic effects on humans (1)	• flammable liquid (DOT) • incompatible with strong oxidizers (1) • toxic vapors and gases may result in fire (1) • may attack plastics, rubber & coatings (1) may react with aluminum at high temperatures (1) • no water criteria set, but EPA suggests ambient limit 2,070 ug/l (3)	• Hazardous Waste (EPA) • Disposal Recommendations: 1. absorb on vermiculite, etc. and dispose in secure sanitary landfill (1) 2. atomize in suitable combustion chamber (1) 3. incinerate (3)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

A. Alcohols (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Isopropyl Alcohol	• used as solvent (37%) & as starting material for acetone (47%) (13) • most solvent used in industrial processes, also as wash solvent, diluent, cleaning solvent, etc.	127 million pounds/yr (13) 24% of alcohol produced is isopropyl alcohol	Inhalation: -PEL (air): 400 ppm TWA (980 mg/m^3) (1) -NIOSH recommends 400 ppm TWA w/ceiling 800 ppm for 15 min. (1) -tentative STEL: 500ppm -IDLH: 20,000 ppm (3) -adequate warning properties	• short term: irritation of mucous membranes -ingestion results in drowsiness, unconsciousness and death (narcosis) (1) • long term: drying/cracking of skin No chronic systemic effects in humans reported (1) • some suspicion of carcinogenic properties unsubstantiated	•incompatible w/strong oxidizers (1) •toxic gases & vapors released in fire (1) •may attack some forms of plastic, rubber & coatings (1) •flammable •no criteria set, but EPA suggests ambient goal of 13,500 ug/l (3)	Disposal recommendations: 1. absorb & dispose in secure sanitary landfill (1) 2. atomize in combustion chamber (1) 3. Incinerate (3)
Ethyl Alcohol	•synonyms: ethanol; cologne spirits; grain alcohol • natural & synthetic sources (13) • used as intermediate in industrial processes, and as solvent (solvent used mostly in shellac, shellac thinners & nitrocellulose laquers (13).	200 million pounds/yr (13) 38% of alcohol produced is ethyl alcohol	Inhalation: - PEL (air): 1,000ppm (3) • Toxic Dose: - Oral rat LD_{50}: 14g/kg (12) - Oral human LD_{LO}: 500mg/kg (12)	• denatured is almost always toxic • eye, nose irritant at very high concentrations (3) • skin contact w/liquid can cause dermatitis • liver damage from chronic ingestion • prolonged inhalation can cause headache, drowsiness, fatigue & tremors (3)	• flammable • dangerous to aquatic life in high concentrations (5) • aquatic toxicant rating: TL_m 96:> 1,000ppm (12) • no criteria, but EPA suggested ambient goal-26,000 ug/l (3)	Incineration (3)

PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

B. Aliphatic and Aromatic Hydrocarbons

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Mineral Spirits	• synonyms: Stoddard solvent; white spirits; safety solvent; naphtha; etc. • straight-chain aliphatic hydrocarbons with boiling range 300-400°F. • usually contains some aromatics as well • used mainly in medium oil & long oil alkyl resin paints and alone as solvent (13)	• 755 million pounds/yr • 113 million gals/yr (13) • 41% of aliphatic HC sold are mineral spirits (13)	• moderate toxicity via skin and inhalation • high via ingestion (6) • inhalation: -PEL (air): 500 ppm TWA (12) -NIOSH recommends 350 mg/m^3 TWA with ceiling of 1800 mg/m^3 for 15 min. (12) -TLV (air): 100 ppm -can be detected (odor) below the PEL, therefore good warning properties (1).	• primary skin irritant, eye, nose, throat irritant, lung irritant, narcotic (6) • very high air concentrations may cause unconsciousness & death (1)	• flammable • incompatible with strong oxidizing agents (1) • toxic gases and vapors may be released in fire (1) • will attack some forms of plastics, rubber & coating (1)	Disposal Recommendations: absorb in vermiculite, dry sand or similar material & dispose in secure sanitary landfill (1)
Petroleum ether	• synonyms: rubber solvent; naphtha; benzin; petroleum naphtha; etc. • straight chain aliphatic hydrocarbons w/boiling range 95-176°F (9) • solvent use • made from American coal oil & consists chiefly of pentane, hexane & heptane (12)	Unknown	• moderate via skin; high via inhalation & ingestion (6) • inhlaation: -PEL (all petroleum naphthas): 500 ppm (2,000 mg/m^3) (3) -IDLH: 10,000 ppm (3) -NIOSH recommends 350 mg/m^3 TWA with ceiling 1800 mg/m^3 for 15 minutes -TLV (air) 100 ppm (3)	• primary skin irritant • eye, nose, throat, lung irritant nervous system damage • narcotic (6) • if confined against skin can cause burns (9); percutaneous absorption not important (3) • because of high volatility, if ingested or aspirated should vaporize quickly • in rats, result of aspiration is displacement of oxygen from lungs & consequent anorexia with cardiac arrest and/or brain damage (9)	volatile incompatible with strong oxidizers (3) combustible liquid (DOT) (12)	Incineration (3)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

B. Aliphatics and Aromatic Hydrocarbons (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Toluene	● synonyms: toluol; phenylmethane; methyl benzene; methyl benzol. ● 30-40% of toluene produced is backblended into gasoline; >50% used to produce benzene & other chemicals; 10% sold as solvent (3)	estimate: 575 million pounds/yr 79 million gallons/yr (13)	● moderate toxicity thru skin, high toxicity thru inhalation & ingestion (2) -inhalation: -PEL: 200 ppm averaged over 8 hr. shift (TWA) not to exceed 300 ppm -NIOSH recommends lowering to 100 ppm TWA with 200 ppm ceiling (1) ● water criteria (AWC): to protect human health 14.3 mg/l (3)	● acute exposure: CNS depression (9), irritant of nose, throat, narcosis (2) ● long-term exposure: drying & cracking of skin (1) ● evidence that toluene has weak promoting effect on DMBA-initiated skin carcinogenesis (9) ● rats: damages chromosomes in bone marrow cells (9) ● some neuromuscular deficiencies reported in males chronically exposed (9) ● possible chronic liver & kidney damage (2)	● acutely toxic to freshwater fish ● AWC-12.4 mg/l (7) ● Hazardous substance (EPA) ● Priority pollutant (EPA) ● water criteria: (AWC) -to protect freshwater life 17,500 ug/l (acute) -to protect saltwater life 6,300 ug/l (acute) 5,000 ug/l (chronic) (3) ● found in fish caught in harbors in vicinities of petrochemical industries ● volatile; in atmosphere, degraded to benzaldehyde & peroxybenzoyl nitrate--can re-enter hydrosphere by rain (7) ● subject to photochemical degradation (7)	● Hazardous Waste (EPA) ● Disposal recommendation: incinerate (3) ● Disposal poses inhalation problem In an unsecured landfill, it may be leached by rain (highly water soluble) (4)
VM + P Naphthas	● synonyms: petroleum spirits; ligroin; painter's naphtha; refined solvent; naphtha; etc. ● straight-chain aliphatic hydrocarbon, boiling range 200-300° F (see Appendix A). -usually contains some aromatics ● used mainly in medium oil and long oil alkyd resin paints -also as straight solvent	VM + P naphtha ● 190 million pounds/yr ● 31 million gals/yr ● approx 49% of all aliphatic hydrocarbons sold are "VM + P naphthas"	● toxic dose: -oral human LD_{LO}: 500 mg/kg -inhalation human: TC_{LO}: 600 mg/m^3 -PEL (air): (all petroleum distillates) 2,000 mg/m^3 (TWA) -NIOSH recommends PEL reduced 350 mg/m^3 TWA -odor thresholds are below the individual properties.	● short term exposure: CNS depression, irritation, of eyes, throat & skin ● long-term exposure: drying & cracking of skin.	● aquatic toxicity rating: TL_m 96: > 1,000 ppm ● extremely flammable and combustible ● volatile ● effect of low concentrations on aquatic life unknown.	● also within this boiling point range falls laquer diluent (200-250° F.) laquer diluent ● 150 million pounds/yr ● 24 million gals/yr ● approx 60% of all aliphatic hydrocarbons sold are classified as "laquer

PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

B. Aliphatic and Aromatic Hydrocarbons (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Xylene	•derived from petroleum •65% of xylene produced is used to make other chemicals -26% is backblended into gasoline -9% is used as solvent	•estimate 495 million pounds/yr 68 million gals/yr	•moderate toxicity thru skin high via inhalation & ingestion •inhalation: -PEL (air): 100 ppm TWA (435 mg/m^3) (1) -NIOSH recommends 100 ppm with ceiling 200 ppm for 10 min. (12) •toxic dose: -oral human LD_{LO}: 50 mg/kg (11) -oral rat LD_{50}: 4300 mg/kg (12) •good warning properties (1).	•eye, nose, throat irritant (1) •narcosis at high concentrations •mild toxicity to blood system of mammals (1) •exposure to high concentrations causes dizziness, drowsiness, uncoordination if exposed to >200ppm, results in anorexia, nausea, vomiting, abdominal pain (1) •liver and kidney damage •selected by NCI for carcinogenesis bioassay (9/78) (12)	•unstable-high temps may cause containers to burst (1) •incompatible with strong oxidizers - may result in fire, explosions •release toxic gases and vapors in fire (1) •will attack some forms of rubber, plastic & coatings (1) • harmful to aquatic life in very low concentrations (5) •aquatic toxicity rating: TL_m96: 100-10ppm (12)	•Disposal recommendations: 1. atomize in suitable combustion chamber (1) 2. absorb & evaporate in fume hood (3) •do not put down sewer due to possibility of combustion

C. Ketones and Esters

Acetone	•used as wash thinner, stripper, and in acrylic & nitrocellulose laquers	190 million pounds/yr 18% of Ketones and esters produced is acetone	•moderate via ingestion and inhalation very low via dermal (2) •inhalation: -PEL (air): 1000 ppm (2400 mg/m^3) (3) -ACGIH recommends 750ppm TWA (1870 mg/m^3) (3) -and STEL of 1000 ppm (2400 mg/m^3) -IDLH: 20,000 ppm (3) -NIOSH recommends 590 mg/m^3 TWA.	•repeated exposure to 25-920 ppm: chronic conjunctivitis, bronchitis, gastritis, gastroduodenitis (14) •headache from prolonged inhalation (2) •no long-term effects known (6)	•flammable •incompatible with oxidizing materials & acids (3) •dangerous to aquatic life in high concentrations (5) •aquatic toxicity rating: TL_m96: > 1,000ppm (12) • no AMC set	•Hazardous waste (EPA) •Disposal recommendations: Incineration (3)

PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

C. Ketones and Esters (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Butyl Acetate	•used in nitrocellulose and other laquers: -n-butyl→ laquers -sec-butyl → nitrocellulose solvent -tert-butyl→ solvent -isobutyl → nitrocellulose solvent (see Appendix A)	98 million pounds/yr	•low via dermal moderate via inhalation & ingestion •inhalation: -PEL (air): 150 ppm TWA (710 mg/m^3) (1) -STEL: 200 ppm -IDLH: 10,000 ppm (3) -good warning properties	•mild irritant and allergen •eye, nose, throat irritant •mildly narcotic (2) •severe overexposure can result in weakness, drowsiness & unconsciousness (1) •long-term effect: irritation of skin (1)	•Hazardous substance (EPA) (3) •flammable •incompatible w/nitrates, strong oxidizers, strong alkalis, strong acids (1) •toxic gases & vapors may be released in fire (1) •will dissolve many plastics, resins & coatings (1) •effect of low concentrations on aquatic life unknown-fouling to shoreline (5)	•Disposal recommendation: 1. absorb on paper towels & evaporate under fume hood (1) (spill) 2. absorb on vermiculite, etc. & dispose in secure sanitary landfill (1) 3. atomize in combustion chamber (1) 4. incinerate (3) 5. should not go down sewer because of possibility of explosion

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

C. Ketones and Esters (continued)

	Found in/Synonyms	Consumption	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Methyl Isobutyl Ketone	•synonyms: MIBK; 2-pentanone; 4-methyl-hexone. •used as thinner for cellulose & other synthetic resins.	112 million pounds/yr (13) 11% of ketones & esters produced is MIBK	•inhalation: -PEL (air): 100 ppm TWA (410 mg/m^3) -NIOSH recommends 50ppm TWA (3) -ACGIH recommends STEL 75 ppm (3) -IDLH - 3000 ppm (3) •toxic dose: -oral rat LD_{50} 0.5-5.0 g/kg (5)	•mild irritant (5) high concentrations can result in narcosis, coma (3) long-term exposure: dermititis (3)	•flammable •incompatible w/strong oxidizers (3) •effect of low concentrations on aquatic life unknown. •may be dangerous if enters water intake (5)	•Hazardous Waste (EPA) •Disposal recommendations: incineration (3) •consumption increasing due to trend toward high-solid coatings, which require stronger solvents (13)
Ethyl Acetate	•sold in solutions w/ ethyl alcohol- available in varying levels of purity •used as solvent in cellulosic resins, shellac & vinyl resins.	112 million pounds/yr. (13)	•low via dermal moderate via inhalation & ingestion (6) •inhalation: -PEL (air): 400 ppm (1400 mg/m^3) (5) -IDLH: 10,000 ppm (3) -Short term exposure: 1,000 ppm for 15 min (5) •toxic dose: LD_{50} 0.5-5.0 g/kg (5)	•irritant to mucous membranes, eyes, gums, and respiratory tract •mildly narcotic (6)	•volatile •flammable •incompatible with nitrates, strong oxidizers, strong alkalis, strong acids •effect of low concentrations on aquatic life unknown--may be dangerous if enters water intake (5)	•Hazardous Waste (EPA) •Disposal recommendation: incineration (3)

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Table 21: SOLVENTS

C. Ketones and Esters (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Methyl Ethyl Ketone	•synonyms: MEK; 2-Butanone; methyl acetone; etc. •used as solvent in paints: 50%-vinyl coatings 18%-acrylic coatings 21%-nitrocellulose 11%-miscellaneous (13)	367 million pounds/yr 35% of ketones & esters sold is MEK	•moderate toxicity via dermal & inhalation •low toxicity via ingestion •inhalation: -PEL (air): 200 ppm TWA -NIOSH recommends 590 mg/m^3 TWA •toxic dose: -oral rat LD_{50}: 3400 mg/kg -oral human LD_{LO}: 500 mg/kg -skin rabbit LD_{50}: 13000 mg/kg	•strong irritant of mucous membranes •affects peripheral nervous system and CNS (2) •rapidly absorbed by inhalation, may cause narcosis (8) •long term exposure: dermatitis (6) •no high degree of chronic toxicity shown (2)	•highly flammable (12) •very soluble in water (8) •dangerous to aquatic life in high concentrations •aquatic toxicity: -freshwater: TL_m 48- -5640 mg/l (bluegill) (5) •no potential for food chain concentrations (5) •may be dangerous if enters water intakes (5)	

D. Other Solvents

	Found in/Synonyms	Consumption	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Propylene Glycol	•synonyms: 1,2-propanediol; methyl ethylene glycol; etc. •used in formulation of water-based (latex paints) (13).	38 million pounds/yr (13)	•inhalation: non-toxic •ingestion: -oral mouse LD_{50}: 0.5-5 g/kg (5) -oral child TD_{LO}: 91 mg/kg (12)	•vapors non-irritating, harmless to skin (5) •incomplete submission of NCI carcinogenesis bioassay results as of 12/78 (12)	•combustible •aquatic toxicity rating: TL_m 96: > 1,000 ppm (12)	

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Table 21: SOLVENTS

D. Other Solvents (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations other comments
Cresol	•source: mixture of 3 isomeric cresols, o-, m- and p-cresols synonym: cresylic acid	estimate 18-20 million pounds/year (13)	•moderate toxicity via oral & inhalation (2) -absorbed thru the skin (6) •inhalation: -PEL (air): 5 ppm (22 mg/m^3) (3) -odor threshold - 5ppm •toxic dose: -oral rat, rabbit LD_{50}: 0.5-5 g/kg (5)	•vapor mild irritant-effects temporary •hazardous substance (EPA) •local effect - corrosion to tissue •repeated or prolonged exposure in small concentrations may cause skin rash & discoloration (3) If extensive exposure, may result in death (3) •chronic systemic poisoning vomiting, headache, loss appetite, mental disburbances, death (3)	•corrosive & combustible •incompatible w/strong oxidizers (3) •toxic gases may be produced in fire (5) •harmful to aquatic life in very low concentrations (5) •aquatic toxicity: -freshwater TL_m 96 hr (bluegill) - 24 mg/l -saltwater LC_{50} 48 hr (shrimp) 10-100 ppm (5) •no criteria, but EPA suggests ambient concentration 304 ug/l	•Hazardous waste (EPA) •Disposal recommendations: Incineration (3)

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Table 21: SOLVENTS

D. Other Solvents (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendati other commen
2. Ethylene Glycol	•used in formulation of water-based (latex paints •also major component of "antifreeze".	61 million pounds/yr (13)	•high toxicity via ingestion moderate via skin low via inhalation •inhalation: -PEL (air): 100 ppm (5) -ACGIH recommends TLV 10 mg/m^3 with ceiling of 55 ppm (125 mg/m^3) (3) •toxic dose: -LD_{50} (rat, mouse, guinea pig: 5-15 g/kg (5)	•vapor is non-irritating, harmless to skin (5) unless heated •inhalation results in CNS depression & dysfunction of blood system (3) •fatal kidney injury if ingested (5) •3 oz can be fatal for humans	•combustible •effect of low concentrations on aquatic life unknown-may be dangerous if enters water intakes (5) •aquatic toxicity: -saltwater LC_{50} (48 hr) shrimp > 100 ppm (5) •no criteria but EPA suggests goal of 140 ug/l (3).	•essential in latex paints for freeze-thaw stabili and coalescence (13)
3. Eth ne Gl Mon yl Et	•synonym: 2-butoxy-ethanol •used as solvent in acrylic & cellulosic resin paints.	Estimate: About 80 million lbs/yr. (13)	•inhalation: -PEL (air): 50 ppm (5) •toxic dose: -oral rat LD_{50}: 0-5 - 5 g/kg (5) -oral human LD_{LO}: 50 mg/kg (12)	•vapors cause slight smarting of eyes or respiratory system if present in high concentrations or temperatures (5) •long term effects - data not available	•combustible •aquatic toxicity: TL_m 24 (brine shrimp): 1000 ppm •no food chain concentration potential	

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Table 21: SOLVENTS

D. Other Solvents (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Methylene Chloride	• used in paint remover aerosol paint products, metal degreasers, etc.	Estimate: 17 million lbs/yr (may be as much as 45 million lbs/yr) (13)	• carcinogen- (potential-EPA) • inhalation: -PEL (air): 500 ppm TWA ceiling 1,000 ppm max. peak 2,000 ppm for 5 min. in any 2 hr period. -NIOSH recommends 75 ppm TWA w/ceiling 500 ppm for 15 minutes (3) -STEL: 500 ppm (1700 mg/m^3) -IDLH: 5,000 ppm (3) -poor warning properties (1) • water quality criteria (AWC): to protect human health- preferably zero. Additional lifetime cancer risk of 1:1,000,000 results at levels of 1.9 ug/l (3).	• metabolic product of methylene chloride is carbon monoxide • repeated contact can result in dermititis (3) • liquid & vapor irritating to eyes & lungs at high concentrations • may cause burns if liquid held in contact w/skin • mild narcotic (3) • anaesthetic- inhalation causes mental confusion, nausea, headache, if continue, → → unconsciousness & death (1)	• Priority pollutant (EPA) • nonflammable • incompatible with strong oxidizers, strong caustics, & chemically active metals (Al, Mg, Na, K.) (3) • may release toxic gases (hydrogen chloride, phosgene, carbon monoxide) in fire(1) • will attack some plastics, rubber & coatings (1)	• increasing use in aerosol products as being substituted for trichloroethylene and fluorocarbon propollents (13) • Hazardous waste (EPA) • Disposal recommendations: 1. incinerate with precautions (see 1,1,1 trichloroethane) (3) 2. collect for reclamation (1) 3. absorb in vermiculite, etc. & dispose at sanitary landfill (1)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

D. Other Solvents (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Perchloro-ethylene	•synonyms: tetrachloroethylene; carbon dichloride; PCE; ethylene trichloride, etc. •used in dip and spray coatings, paint removers and strippers (13)	Unknown	•moderate toxicity via skin high via inhalation & ingestion (6) •inhalation: -PEL (air): 100 ppm TWA (3) ceiling: 200 ppm max. peaks: 300 ppm for 5 min. in 3 hrs. (3) -NIOSH recommends 50 ppm TWA, w/ceiling 100 ppm for 15 min. (3) (this will not prevent carcinogenic effects) -IDLH: 500 ppm (3) •water criteria: to protect human health-prefereably zero; additional lifetime cancer risk of 1:100,000 posed by concentration of 8.0 ug/l (3).	•toxic by inhalation, prolonged or repeated contact w/skin, and ingestion(2) •mutagenic (bacterial bioassays) and carcinogenic (mice) •not teratogenic (9) •NCI positive carcinogen •chronic exposure at high levels causes mild intoxication and liver dysfunction (9) •systemic effects: CNS depression, hepatic injury & anesthetic death (3)	•Priority pollutant (EPA) •incompatible w/strong oxidizers & chemically active metals (lithium, barium, beryllium) (3). -reacts violently w/ concentrated nitric acid(3) •permissible concentrations in water (AWC): -freshwater- 5,280 ug/l (acute) 840 ug/l (chronic) -saltwater - 10,200 ug/l (acute) 450 ug/l (chronic) (3) •slight bioconcentration (9)	•Hazardous waste (EPA) •Disposal recommendations: 1. incineration, w/precautions (see 1,1,1 trichloroethane) (3) 2. may be recovered and reused (3)

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Table 21: SOLVENTS

D. Other Solvents (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
1,1,1 Trichloro ethane	●synonyms: methyl chloroform, MC ●used in dip & spray coatings, paint removers & strippers	1976 production 3,000 kg/yr (9)	●moderate toxicity (6) ●inhalation: -PEL (air): 350 ppm (1900 mg/m^3) (9) -NIOSH recommends 200 ppm (3) -STEL - 450 ppm (2380 mg/m^3) -IDLH - 1,000 ppm (3) ●water criteria (AWC): to protect human health 1,030,000 ug/l (3)	●liquid & vapor irritating to eyes on contact (3) ●inhalation can cause psych-physiologic effects (9) ●liver & kidney damage at high concentrations (9) ●in vitro studies indicated slightly mutagenic (9) ●narcotic; acute exposures result in CNS depression, may cause cardiac arrest (3)	●Priority pollutant (EPA) ●volatile (9) ●incompatible w/strong oxidizers & chemically active metals (Al, Mg. Mg, K) (3). ●upon contact w/hot metal or exposure to UV radiation, decomposes to produce irritating gases (hydrochloric acid, phosgene & dichloroacetylene) (3) ●microbial degradation not demonstrated (9) ●moderately toxic to aquatic life (9) ●water criteria (AWC): freshwater: 18,000ug/l (acute) saltwater: 31,200 ug/l (acute) (3) ●extremely persistent in groundwater	●Hazardous Waste (EPA) ●Disposal recommendations: 1. incineration, preferably after mixing w/other combustible fuel; care must be exercised to assure complete combustion to prevent formation of toxic phosgene gas; need to use acid scrubber to remove halo acids (3) 2. may be recovered & recycled (2)

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 21: SOLVENTS

D. Other Solvents (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Turpentine	•synonyms: gum spirits of turpentine, turps, sulfate wood turpentine, etc. •used as paint thinner & brush cleaner	•estimated: 25 million gallons/yr (amount used in paints 50,000 gal) (13)	•high via ingestion moderate via inhalation & dermal; some skin absorption (6) •inhalation: -PEL (air): 100 ppm (560 mg/m^3) (3) -STEL: 150 ppm (840 mg/m^3) -IDLH: 1900 ppm (3) •inhalation: -inhalation rat LC_{50} 3590 ppm (1) -oral rat LD_{50} 0.5-5 g/kg (5) -good warning properties	•eye, nose, throat, skin irritant, skin allergen •vapors cause headache, confusion, respiratory distress •If liquid aspirated into lungs can cause fatal pulmonary edema (5) •irritant to kidneys--repeated exposures to high concentrations can cause chronic nephritis, predisposition to pneumonia (3) •poisonous if swallowed	•combustible •incompatible with strong oxidizers & chlorine (3) •may release toxic gases in a fire (1) •will attack some plastics, rubber, coatings (1) •dangerous to aquatic life in high concentrations-fouling to shoreline (5) •aquatic toxicity: -freshwater: toxic to fish at 100 ppm (time period not specified) (5) •no water criteria	•Disposal recommendations: (1) Incineration (3) (2) Absorb on vermiculite, etc and dispose in sanitary landfill (1) Atomize in suitable combustion chamber (1)

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Table 22: WOOD PRESERVATIVES

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Penta-chlorophenol (PCP)	• synonyms: Penta, PCP • found in wood preservatives • commercial PCP may be contaminated with dioxin compounds, which are much more toxic than PCP. *PCP also listed in Pesticides Section.	**Unknown**	• inhalation: -PEL - 0.5 mg/m^3 -STEL - 1.5 mg/m^3 -IDLH - 150 mg/m^3 (3) • toxic dose: -LC_{50} - 50-500 mg/kg - rat (5) • good warning properties • water criteria: -to protect human health 1,010 ug/l set by EPA based on toxicity 30 ug/l set on organoleptic basis -no adverse effect level in drinking water 21 ug/l (3)	• Hazardous substance (EPA) • hazards via inhalation, skin absorbtion, ingestion eye & skin contact (3) • not considered carcinogenic but RPAR issued 10/78 on basis of fetotoxicity and teratogenicity (3) • effects of exposure: muscle weakness, headache, loss of appetite, abdominal pain, irritant to mucous membranes • concentrates in liver, kidney & intestine (4) • causes 1st and sometimes 2ndary burns on exposure • repeated exposures may cause chloracne-type skin rash & liver damage (1)	• Priority pollutant (EPA) • incompatible with strong oxidizers • in fire, may release toxic gases and vapors, such as hydrochloric acid, chlorinated phenols & carbon monoxide (3) • toxic effects in environment: -freshwater - 5ppm/3 hrs/ trout/lethal -waterfowl - 4500 ppm/ LC_{50} /mallards (5) • criteria set: - to protect freshwater 55 ug/l (acute) 3.2 ug/l (chronic) - to protect saltwater 53 ug/l (acute) 34 ug/l (chronic) • known to persist (3) in warm moist soil for 12 mos (7) • bioconcentrates in freshwater/saltwater vertebrates (50%) (7)	• EPA-designated Hazardous Waste • Recommendations for disposal: incinerate (600-900°C), coupled with adequate scrubbing and ash disposal facilities (3) - PCP in waste waters may be recovered and recycled

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Table 22: WOOD PRESERVATIVES (continued)

	Found in/Synonyms	Consumption	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Chlorinated Phenols	•found in wood preservatives e.g., 2-chlorophenol 2,4-Dichlorophenol 2,6-Dichlorophenol 2,4,5-Trichlorophenol	Unknown	•high toxicity via oral, dermal see PCP for comparable toxicities	•dermatitis •CNS depression (2) •absorption from spilling solution on skin may be "very rapid" → death could result in 30 minutes from 64 sq. in. coverage (2) •damage to kidneys, liver, spleen, pancreas, edema of lungs.	•fish & other aquatic organisms showed wide range of sensitivity; acute toxic values were at moderate levels compared to other priority pollutants (4). •acute toxicity increases with chlorination •odors and tainting of fish flesh at low concentrations (7) •when heated, tetrachlorophenol emits highly toxic fumes.	•dioxins may be formed during chemical synthesis, the amount formed depending on temperature & pressure controls of reaction.
Copper Naphthenate	•synonyms: naphthenic acid, copper salt. •found in wood preservatives, paint driers	Unknown	•toxic dose: -oral rat LD_{50} 4-6 g/kg (5) •inhalation: -TLV - 500 ppm	•eye, skin, lung irritant •ingestion result in stomach irritation •aspiration causes severe lung irritation & rapidly developing pulmonary edema (5) •causes CNS excitement, followed by depression (5) •possible carcinogen (2) •toxicity due chiefly to impurities or solvent (9)	•combustible •harmful to aquatic life in very low concentrations, fouling to shoreline (5) •freshwater effects: 2.0 ppm/72 hr/blue-green algae/100 % kill •supposedly copper is absorbed into wood & remains immobile when naphthenate evaporates.	

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Table 22: WOOD PRESERVATIVES (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Creosote	•found in wood preservatives	estimate 1972 production 575,000 tons by 6 companies in 25 sites	•toxic dose: -oral rat LD_{50}: 725 mg/kg -LD_{LO}: rabbit 600 mg/kg •inhalation: -NIOSH recommends 0.1 mg/m^3 TWA (8) •moderately to slightly toxic •TL_m 96: 1-10 ppm (8)	• absorbed through skin & mucous membranes • vapors cause eye and nasal irritation • serious systemic effects with ingestion (cardio-vascular collapse and death) • EPA-CAG reports as skin carcinogen (8)	• low evaporation rate - no significant air pollution from vapors (10) • incompatible with strong oxidizers (3) • overall degradation rate same as microbial • considered stable in groundwater (8) • creosote migrates from treated wood into environment, but impact unknown • RPAR issued (8)	• EPA designated Hazardous Waste • Disposal recommendation: Incineration(3)
Magnesium fluoro-silicate	•found in wood preservatives	Unknown	•high toxicity via ingestion (2) •toxic dose: -oral guinea pig LD_{50}- 200 mg/kg (12) -subcutaneous frog LD_{LO} - 420 mg/kg (12) •inhalation: -NIOSH recommends 2.5 mg/m^3 TWA (12)	Unknown	Unknown	

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PAINT PRODUCTS TECHNICAL INFORMATION

Table 22: WOOD PRESERVATIVES (continued)

	Found in/Synonyms	Consumption	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Naphthenic Acid	•found in wood preservatives	Unknown	•inhalation: -TLV: 10 mg/m^3 (5) •toxic dose: -oral rat LD_{50}: 3,000 mg/kg (12)	•vapor and liquid irritating to eyes, nose & throat - excessive exposure can cause dermatitis (5) •moderate toxicity via ingestion	•combustible •harmful to aquatic life in very low concentrations -freshwater: 5-50 ppm/ 18-60 hr/crayfish/lethal -freshwater: 5.6 ppm/ 96 hr/bluegill/TL_m	
Zinc Naphthenate	•synonyms: naphthenic acid, zinc salt. •found in wood preservatives	Unknown	•low acute oral toxicity (9) moderate toxicity via ingestion •toxic dose: -oral rat LD_{LO}: 5,000 mg/kg (12) -oral rat LD_{50} : 4,920 mg/kg (12)	•not primary skin irritant •not recognized sensitizing agent (9)	Unknown See copper naphthenate	

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Citations for Tables 19-22, "Paint Products Technical Information"

1. Mackison et al., 1981.
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15. Fritsch, 1978.

SECTION IV

HOUSEHOLD CLEANERS

A. BACKGROUND INFORMATION

1. Definitions

The study of household cleaners is in many ways much more complex than either pesticides or paint products. Unlike paint products, information on cleaning chemicals is usually difficult to discover and inconclusive when found.

When we speak of household cleaners, we are referring to an entire range of cleaning and disinfecting products. These would include disinfectants, bathroom cleaners, drain cleaners, furniture polish, dry cleaning fluid, bleach, oven cleaners, abrasive powders, air fresheners, floor cleaners and waxes, rug cleaners, upholstery cleaners and window cleaners, as well as laundry products such as detergents, fabric softeners and additives. It is this bewildering profusion of cleaners that makes this class of products so difficult to examine. Within each type of product, there are additionally tens and sometimes hundreds of different formulations for specific uses and/or brands.

A few of the ingredients found in all cleaners need some further definition.

a. Detergents. Detergents are substances that clean due to a combination of properties: they lower the surface tension, provide wetting, emulsifying and dispersing action, and make foam. Ordinary soap is a kind of detergent. Usually, however, the term "detergent" refers to synthetic soaps. Detergents, whether for laundry or dishwashing, solid or liquid, have certain ingredients:

- Surface Active Agents, or "surfactants," alter energy relations at interfaces, lowering the surface tension of a given solution (Gosselin et al., 1976), permitting the fabric to be wetted and allowing for loosening and removal of soil. The same chemical compound may be used as a detergent, an emulsifier, a wetter or a penetrant. A typical laundry detergent contains 14-20 percent surfactants (Fritsch, 1978).

  There are three kinds of surfactants, depending on their ionization at neutral pH: anionic (negatively charged), cationic (positively charged), and nonionic (neutral). Within these three classes there is a wide range of chemical structures and toxicities (Gosselin et al., 1976):

- -- Anionic surfactants form precipitates with calcium ions and, in mineral-rich ("hard") water, must be used with builders (see below). Typical anionic surfactants: linear alkyl benzene sulfonate (see Table 33) and alkyl sodium sulfonate.
- -- Cationic surfactants are used as germicides and sanitizers. Also called quaternary ammonium compounds (QACs), they consist of alkyl- and/or aryl-substituted ammonium chloride or bromide. One of the alkyl groups is usually a long, hydrophobic carbon chain (Gosselin *et al*., 1976). Some common cationic surfactants are benzalkonium chloride (see Table 33) and alkyl dimethyl ethyl benzyl ammonium chloride.
- -- Nonionic surfactants are reaction products of alkylated phenols or fatty alcohols with varying amounts of ethylene oxide (Gosselin *et al*., 1976). They have one hydrophobic end (alkyl chain) and one hydrophilic end (polyglycol); this structure provides the surface active properties. Typical nonionic surfactants are alkyl ethoxylate (see Table 33) and glyceryl monostearate.

- *Builders*, sometimes called sequestrants, are a major component of detergents which perform three functions: 1) remove (sequester) the calcium and magnesium found in hard water, thereby allowing the surfactants to work, 2) prevent soil from re-depositing, and 3) preserve the enamel on the inside of the washing machines from corrosion through an anti-caking ingredient (such as sodium silicate). Builders are of two general types:

  - -- Those that hold the calcium in solution as *soluble chelates*, such as sodium tripolyphosphate; and
  - -- Those that *precipitate* the calcium out, such as sodium carbonate, sodium metasilicate and sodium sesquicarbonate (see Table 34).

Laundry detergent usually contains 40-60 percent sequestering agent, 0.5-0.9 percent anti-redisposition agent, and 5-7 percent anti-caking agent (Fritsch, 1978).

- *Optical brighteners* convert some invisible ultraviolet sunlight to visible blue light, thereby making the fabrics appear whiter. Optical brighteners constitute a small percentage by volume (0.3-0.75 percent) of the laundry detergent (Fritsch, 1978).

- *Other* ingredients are also added to detergents, such as fillers, foam boosters and perfumes. Fillers are "inert" substances (see discussion below) which provide bulk and alkalinity. Foam boosters add sudsiness, and perfumes, of course, add a fresh or scented smell.

b. Disinfectants. True disinfectants are designed to be harmful to life in some form (usually microbial), and are therefore toxic. Many people assume that a disinfected site is "germ-free;" however, only sterilization can remove all microbes -- disinfection only reduces the number of germs and bacteria temporarily.

Cresols and phenols have been widely used as disinfecting agents for a long time. Cresol, which should not be confused with creosol (one of the active ingredients of wood "creosote" preservatives), is obtained from coal tar. Cresol is very injurious to humans, may be absorbed through the skin, and accounts for many poisoning cases (see Table 21 for complete hazards). Dilute phenol solutions have been used since the 1870's as antiseptics in surgery, for wound dressings, etc. Phenol is now recognized as a poison which is toxic to all cells, and its repeated use on skin is now discouraged (Gosselin et al., 1976).

There is some confusion as to terminology that deserves examination. An early antiseptic preparation of phenol made by boiling heavy tar oils with a strong alkali was known as "lysol" (Gosselin et al., 1976). In England the name lysol still refers to a cresol and soap solution, which is extremely toxic and corrosive. In the U.S., Lysol® disinfectant is a registered trademark, and it contains soap and low concentrations of substituted phenolic compounds (e.g., o-phenyl phenol, o-benzyl-p-chlorophenol) which are much less toxic that the crude cresol oils.

Recognizing the dangers of using these extremely toxic substances in household preparations, cresols and phenols are no longer widely used in their raw state. Substituted phenolic compounds (i.e., the base compound to which elements (e.g., chlorine) or organic groups (e.g., methyl, benzyl groups) have been added), are now used in place of phenol, and, while they sometimes pose a hazard due to acute oral toxicity, skin irritation and respiratory effects, in general they are safer than simple phenol. Quaternary Ammonium Compounds (QACs) or cationic surfactants (see above discussion) are generally replacing the cresol compounds in germicides and sanitizers. Not as much is known about the effect of long-term, low level use of these QACs but they are less acutely toxic than cresols and phenols.

c. Undefined Ingredients. A casual glance at the label of most household cleaners will reveal that labeling on these products is usually inadequate for consumer decisions and sometimes misleading. Although there are some legal restrictions on labeling (see below), for the most part these do not concern the actual ingredient listing, which is what the conscientious consumer is usually most interested in (i.e., "what's in this stuff?"). In many cases there is a complete lack of identification of the ingredients. When the ingredients are listed, the terminology used can be misrepresentational. Often the ingredients are defined more by their function than by their content, for instance "grease cutter," "corrosion inhibitor," "polishing agent," "chelator," or "coloring agent." Even the information supplied to Poison Control Centers is often couched in these non-specific terms. In other cases, just a generalized category name is given. A furniture polish label may state that it contains "petroleum distillates" or "aromatic hydrocarbons" when those terms cover a broad range of chemicals with varying toxicities (see Appendix C). A variation on this type of misleading labeling practices is when the product label states what is not found in the product ("no carbon tetrachloride," "no phosphates") without indicating what is contained. Such a label is used when the compound is specifically restricted by law. The practice of using such phrases as "environmentally safe" or "biodegradable," implying that the product is safer than it actually is, is regretably widespread.

An extremely common labeling practice consists of identifying some small percentage of the content as "active" while the remaining percentage is 'inert.' The consumer may readily assume that inert ingredients are totally harmless, such as water or dyes. As Mackay (1979) states, "Ingredients labeled 'inert' by the manufacturer are not necessarily inert from the viewpoint of the toxicologist, physician or public health official" (or the consumer!). The inert ingredient could be methylene chloride in a disinfectant, or toluene in a spot remover. Dusts and powders, such as abrasive cleaners or laundry detergents, often consist mostly of such "inert" ingredients as silica, gypsum, calcium phosphate, talc and magnesium carbonate, which may or may not result in harmful effects.

A satisfactory label -- one occasionally does occur -- should provide the following: 1) complete and accurate listing of the chemicals contained in the product, 2) instructions for the safe use and disposal of the product, and 3) an indication of any special hazards associated with its abuse, environmental effects, or synergistic reactions with other products.

2. Regulatory Framework

There have been several regulatory actions which affect the sale and use of household cleaners. By far the most important is the Federal Hazardous Substances Act, (FHSA), which establishes labeling requirements and allows an outright ban of certain particularly hazardous materials. For a more complete examination of the Act, see Part A of this HHWD series of reports.

As a result of this Act, any household product which contains "hazardous substances" must contain a label with specified precautionary statements, an "active" ingredients list, first aid instructions and other designated information. There are some substances which must also have special labeling; some of these chemicals that may be found in household cleaners are petroleum distillates, acid (e.g., 10 percent hydrochloric, 5 percent carbolic, 10 percent oxalic), bases (e.g., 10 percent potassium hydroxide, 10 percent sodium hydroxide), and ammonia (5 percent). Certain products have also been banned for sale under FHSA; those that used to be found in household cleaning products include: extremely flammable water repellents, carbon tetrachloride, liquid drain cleaners with 10 percent or more potassium hydroxide, and aerosols containing vinyl chloride monomers (though the latter is not technically a "product").

In addition to those products that require special labeling or have been banned, there are a number of products which are being reviewed at this time, including chemical room deodorizers, benzidine dyes, and hydrocarbon aerosol propellents. Of course, this list is constantly changing as products are regulated or determined to be safe.

Benzene has been under investigation for many years, but that review process is now closed. Manufacturers, recognizing the extreme health hazards posed by benzene (see Table 29), have voluntarily taken it out of household products (except gasoline). As with the case of all banned or restricted products, old benzene-containing cleaning products may still be found in some homes.

Products which have some pesticidal function, such as disinfectants and preservatives, are regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). These can be noted on container labels by the "EPA Registrion No."

B. USE OF HOUSEHOLD CLEANERS

1. Volume Estimates

Given the manufacturers' reluctance to release sales information (i.e., volumes sold and used), it is difficult to estimate the extent of use of household cleaners. It is probably safe to assume that it is quite high. In a survey conducted in the Seattle area, 97.5 percent of the respondents said they had household cleaners in their home (see Part C of this series). Table 23 shows a selected listing from a consumer survey of the most-used products sold in supermarkets. Soaps and detergents topped the list, while other cleaning products such as scouring powders and air fresheners were bought by more people than such staple items as milk and butter.

Table 23. CONSUMER SURVEY OF MOST USED PRODUCTS. This is a partial listing of an annual supermarket sales survey, published by Progressive Grocer (1979).

Rank	Item	%Usage
1	Soaps and detergents	97.0
13	Household cleaners	91.7
22	Scouring powder	89.0
25	Furniture polish	87.9
30	Scouring pads	86.4
33	Dishwashing soap	85.4
34	Window cleaner	85.3
35	Bleach	84.4
45	Air fresheners and deodorizers	80.2
57	Bathroom cleaners	79.3
61	Oven cleaners	72.0
64	Insecticides	68.9
67	Drain cleaners	66.5
77	Milk	63.5
78	Soaps for fine fabrics	61.9
79	Fabric softeners	61.4
81	Floor wax	59.3
86	Butter	52.5
84	Rug cleaners	51.2
90	Beer	49.4
105	Kitchen cleaners	43.3
112	Starch	37.4
119	Laundry presoaks	35.3
120	Metal polish	35.2
122	Flea and tick	33.0
131	Aerosol-Pam	29.4
133	Dishwashing (auto detergent)	27.1
147	Household dye	17.7
148	Laundry additives	17.5
162	Meat extenders	6.3

We can get some idea of the volumes through a qualitative analysis of their frequency of use. According to a nationwide review by Hathaway (1980), disinfectants and cleaners are used several times a week or even daily and become part of the wastewater flow. Detergents are used frequently each day and may represent a fairly high concentration of toxicants, depending on the type of detergent used. Laundry products are used frequently but not daily. Obviously, any toxic constituents of these products would be highest on washday, but may continue to show a rather constant concentration throughout the week. All deodorizers are used frequently, but it depends on their use as to whether they enter the waste stream: air fresheners do not directly enter wastewater, while toilet bowl deodorizers are dispensed with every flush. Polishes are used fairly infrequently, perhaps once per week, and probably do not usually enter the waste stream.

Estimates as to the actual volumes of household cleaners which are used and disposed of are somewhat sketchy due to lack of data. The estimates on consumption which were used in Tables 29-37 are from a study on heavy metal content of various household products by Gurnham et al. (1979). Based on an average population per household of 2.525 persons, they computed an average consumption of selected products in grams per capita per day. If we assume a population of the Seattle/King County region of 1.2 million (1980), then Table 24 shows some rough figures on volumes used. Certainly the 25 tons of powder laundry soap and 13 tons of bleach stand out as being significant quantities of products used. It is important to realize, however, that, as an industry group has stated, "These products are mostly water and probably do not represent a significant contribution to the overall waste stream compared to industrial contributions" (emphasis ours) (CSMA, 1982).

2. Routes Into the Environment

Household cleaners contain toxic chemicals that are potentially harmful to human health and the environment. Unlike many other toxic products, household cleaners pose a problem not as much through their disposal as through their use. Cleaners normally are not disposed of, in the sense that excess or leftover quantities of the substances are considered waste, and dumped. Instead, they would tend to enter the environment through their everyday use, and use of these products in many cases results in the chemicals being added to the household wastewater. This could either be a direct addition, such as in drain cleaners, or indirectly, such as with furniture polish, where the cloth that is soaked with polish is subsequently laundered. The use of some of these products can also result in the addition of chemicals into the air, through aerosols or solvent vapors.

Table 24. ESTIMATED CONSUMPTION OF HOUSEHOLD CLEANERS IN THE SEATTLE /KING COUNTY AREA. Rates (g/c/d) are from Gurham et al. (1979). Estimated totals for King County are based on 1980 population of 1.2 million people and are English (short) tons, not metric.

Product	grams/capita/ day	tons/ day	tons/ year
Abrasive cleaners	0.29	.38	140
Disinfectants	0.30	.40	150
Furniture polish	0.07	.09	30
Silver polish	0.07	.09	30
Floor finish	0.02	.03	10
Drain cleaners	0.2	.26	95
Liquid household cleaners	4.15	5.40	2000
Glass cleaners	0.4	.53	190
Toilet bowl cleaners	1.19	1.57	575
Liquid dish detergent	6.17	8.16	2980
Dishwasher detergent	3.62	4.79	1750
Liquid laundry soap	4.40	5.82	2120
Powder laundry soap	19.11	25.28	9230
Fabric softener	10.39	13.74	5010
Liquid cold water wash	0.02	.03	10
Bleach	9.92	13.12	4790
Powder bleach	1.47	1.94	710

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C. ENVIRONMENTAL IMPACT

Does the addition of these household cleaning products to the waste stream constitute an environmental problem? It is difficult to fully answer this question. It has been suggested that these cleaners are second only to cosmetics in contributing toxic substances to household wastewater (Hathaway, 1980). If this wastewater enters an on-site treatment facility (septic tank/-drain field) the potential exists for groundwater contamination and entry into the environment. Some of the chemicals found in cleaners are slow to degrade; this could be a cause for concern. Additionally, many of the chemical constituents are found on EPA's Priority Pollutant, Hazardous Substance, Hazardous Waste, and other lists and their entry into the environment should be minimized.

Household cleaners are almost always acutely toxic to humans. According to the National Clearinghouse for Poison Control Centers (1981), over 17,701 poisoning cases attributed to cleaning and polishing agents were reported in 1979. (This is not, obviously, the total number which occurred, as many cases are not reported at the Poison Control Centers.) Tables 29-37 detail many of the acute effects from household cleaners, ranging from skin irritation, central nervous system depression, respiratory failure, or even death. These acute effects may also occur in organisms found in the aquatic or soil environment, and, if the concentrations were high enough, could result in damage. At this time, however, such effects are speculative only.

Although all of the household cleaning products are known to be acutely toxic, not as much is known about the effects of chronic exposure on humans or the environment. It appears that the majority of the ingredients are biologically unstable and will tend to break down rather quickly. From the studies that have been done, most likewise do not cause serious health problems to humans using them in long-term, low level exposures (although skin irritation and dermatitis are fairly common effects).

1. Organic Solvents

There is an exception to this general rule that cleaning products pose a relatively low hazard to humans or the environment through chronic exposures: organic solvents, including perchloroethylene, petroleum distillates and 1,1,1-trichloroethane. Table 25 shows some of the common organic solvents and the products in which they are found; those that have been reviewed elsewhere in this report for their health and environmental effects are so noted. They produce a wide range of serious chronic effects in humans or test animals including cancer (perchloroethylene), mutations (1,1,1-trichloroethane, perchloroethylene), neuromuscular and narcotic effects (methylene chloride, petroleum distillates,

Table 25. ORGANIC SOLVENTS IN HOUSEHOLD CLEANING PRODUCTS. (Adapted from survey by Mackay, 1979)

Solvent	Product (s)	Where Reviewed
1. Orthodichlorobenzene	Drain degreaser	Not reviewed
2. Paradichlorobenzene	Drain degreaser Toilet bowl deodorizer	Table 30
3. 1,1,1 Trichloroethane	Septic tank drain field cleaner Drain opener Oven cleaner (aerosol) Cleaning fluid Furniture polish	Table 30
4. Trichloroethylene	Cleaning fluid	Not reviewed
5. Perchloroethylene	Laundry degreaser Home and auto parts cleaner	Table 21
6. Aliphatic, Aromatic Hydrocarbons	Septic tank drain field cleaner Laundry degreaser Cleaning fluid Engine degereaser Car wash	Table 21
7. "Petroleum distillates" (see glossary)	Septic tank drain field cleaner Drain opener Oil and grease dissolver Garage degreaser Cleaning fluid Engine degreaser Spray cleaner Floor cleaners Furniture polish Spot remover	Table 21
8. Methylene chloride	Oven cleaner Graffiti remover Brush cleaner	Table 21
9. "harmful organics"	Floor stripper and cleaner	Not reviewed
10. "Chlorinated solvents"	Laundry degreaser	Table 21

other hydrocarbons) and liver and kidney damage (1,1,1-trichloroethane and petroleum distillates). (See Table 21, 29, and 30.)

The use and disposal of organic-containing consumer products is a suspected major source of groundwater contamination. A study by the Nassau County (New York) Health Department of over 500 products in terms of purpose, method of use, ingredients, manufacture, and yearly sales volume (MacKay, 1979) identified 250 products of concern by this following criteria:

- contained (or were suspected of containing) organic chemicals;
- had the potential of entering the groundwater via usage; and
- was used in significant quantities in Nassau County.

A breakdown of these 250 products is shown in Table 26. Some of these, such as paint and varnish removers, are not considered to be household cleaners in our presentation, but can be found in Paint Products (Section III). Products such as septic tank/drain field ("cesspool") cleaners that contain organic solvents and directly enter the groundwater via on-site sewage disposal systems are of the most concern. Others may not be directly disposed of but may indirectly reach the groundwater via surface water runoff. According to Colton *et al*. (1979),

> Nassau County health officials estimate that the typical cesspool and drain cleaner contains 20 percent methylene chloride, 30 percent 1,1,1-trichloroethylene, and petroleum distillates. Other cleaners contain orthodichlorobenzene. Annual usage [of these cesspool and drain cleaners] for Nassau County is estimated at 67,500 gallons. Since the major proportion of these chemicals would be used in unsewered areas, there is significant concern for groundwater quality which is recharged through septic systems and cesspools.

Because of this concern, in August 1978 the New York State Attorney General's office asked the State Supreme Court to ban the sale of two specific cesspool cleaners in Nassau and Suffolk Counties. For more information on this subject, please refer to Part A of the HHWD series of reports.

2. Other Household Cleaning Products

Other specific chemicals found in household cleaners may have the potential for environmental damage. Chlorinated phenolic compounds (such as o-benzyl-p-chlorophenol) are widely used in dis-

Table 26. CONSUMER PRODUCT CONTAINING "CHEMICALS OF CONCERN" NASSAU COUNTY, NEW YORK. (Padar, 1978, in Colton et al., 1979.)

Category	Number of Products	Annual Usage (gallons)	Estimated Quantities of Chemicals of Concern[a] (gallons)
Organic Solvent Cesspool Cleaners and Drain Aids	10	67,500	55,900
Solid Toilet Bowl Deodorizers	14	270,000[b]	267,300[b]
Laundry Degreasers	5	25,300	6,100
Household Cleaners and Disinfectants	40	NA	NA
Oven Cleaners	3	NA	NA
Paint and Varnish Removers	39	21,400	17,100
Solvents and Cleaning Fluids	47	79,800	33,100
Driveway and Garage Degreasers	12	3,000	NA
Spot Removers	10	1,200	800
Engine and Metal Degreasers	23	5,400	NA

Table 26. CONSUMER PRODUCTS CONTAINING "CHEMICALS OF CONCERN" NASSAU COUNTY, NEW YORK. (Continued)

Category	Number of Products	Annual Usage (gallons)	Estimated Quantities of Chemicals of Concern[a] (gallons)
Radiator Flushers	10	NA	NA
Floor Strippers, Cleaners, and Dressings	12	1,200	NA
Car Waxes and Cleaners	17	NA	NA
Miscellaneous	8	NA	NA
Total:	250	205,100 + 270,000[b]	114,000 + 267,300[b]

[a] Does not include petroleum distillates.

[b] Pounds.

[c] NA - Not Available.

infectants (see Table 35). Very little is known about the effects of long-term use, especially in the environment. Their ring structure is quite stable, and therefore would tend to be more persistent. Furthermore, the chlorine atoms on such a stable compound make it very toxic.

Detergents pose a special situation because of the sheer volume of the products used and the well-documented pollution problems associated with their use. A major conflict arose over the use of phosphate chemical builders such as sodium tripolyphosphate, trisodium phosphate, etc. Most laundry detergents sold at the beginning of the 1970's contained 35-50 percent of the builder sodium tripolyphosphate (STP). Total annual use of detergents in the U.S. was about 2.5 million metric tons -- this resulted in one million metric tons of phosphates being released to wastewater (Hodges, 1973). These phosphates contributed to the eutrophication or overenrichment of numerous waterways (exactly how much has been a matter of dispute) resulting in depleted oxygen levels and fish kills. Laundry detergents were not, of course, the sole culprit: fertilizers contain large amounts of phosphates and runoff from fertilized lands contributed to the eutrophication problems. Dishwashing detergents, though not used in as high volumes as laundry detergents, sometimes contain 50 percent or more phosphates (Fritsch, 1978).

The resulting increase in public awareness of the contribution from this source has resulted in the outlawing of the use of phosphate-containing detergents in some areas and to a general reduction in their levels in many detergents. Many consumers have voluntarily switched to low- or no-phosphate detergents. Some products that have been marketed in recent years as being low- or no-phosphate have made use of caustic chemicals such as sodium carbonate and sodium silicate, both of which are capable of producing eye and skin irritation or illness among exposed children (the Surgeon General has come out with a warning against their use (Hodges, 1973)).

Although not technically a "product," the increasing use of aerosols to dispense cleaners poses an acute health hazard. Some aerosol sprays contain organic solvents to dissolve or suspend the substance being sprayed. These solvents include petroleum distillates, toluene, chlorinated hydrocarbons and ketones. Besides being toxic in their own right (see Table 21), organic solvents in aerosol form are an additional hazard because the mist droplets are fine enough to enter the lungs. The substance that is in suspension can be inhaled as well. The particles can remain in the air even after the solvent has evaporated -- for instance, with oven cleaners, the sodium hydroxide can be airborne for hours (McCann, 1979).

The well publicized evidence that use of the propellants dichlorodifluoromethane and trichlorotrifluoromethane (Freon 12 and 11) can cause depletion of the earth's ozone layer has focused attention on the environmental dangers from the use of aerosols. Use of these chlorofluorocarbons in aerosol containers is now banned, as are aerosols containing vinyl chloride monomers. The hydrocarbon aerosol propellants are currently under review for possible regulation.

D. ALTERNATIVES TO HOUSEHOLD CLEANERS

Unlike many other toxic household products (e.g., gasoline or paint), many alternatives exist for the use of safer or more benign household products. Table 27 provides some suggestions and ideas on such alternatives. It is not our intent to fully cover this topic in this report; for those interested in this subject, we suggest the following sources:

- "99 Ways to a Simple Lifestyle" (CSPI, 1977);
- "The Household Pollutants Guide" (Fritsch, 1978);
- "The Formula Book" (Stark, 1975); and
- various pamphlets from the USDA Cooperative Extension

E. INFORMATION ON HOUSEHOLD CLEANING CHEMICALS

1. Study Methods

An investigative method for household cleaners was used similar to those used for other classes of products reviewed in this report. After categorizing the different types (e.g., drain cleaners), we went directly to the retail outlets to mark those brand names most commonly being sold and used. However, unlike many other household toxic products, cleaner manufacturers are not required to list the ingredients of their products on the labels. We were fortunate in that the Poison Control Center at Children's Orthopedic Hospital in Seattle allowed us the use of their "Poisindex." The Poisindex is a listing of all ingestible household products, their ingredients and concentrations. It is updated every six months to provide reliable and accurate information for poisoning cases. As this is confidential information, we are not allowed to list the composition of products by brand name (which is how it appears on the Poisindex). We took these listings of ingredients and reworked them to come up with the list of common household cleaning ingredients that we have reviewed, as seen in Table 28. If these chemicals were found in more than one kind of product (and they often are), this was noted on the Tables. These chemicals were then analyzed as to their human health hazards, environmental effects, and alternatives.

Table 27. SOME ALTERNATIVES TO COMMERCIALLY AVAILABLE HOUSEHOLD CLEANERS.

IF YOU HAVE THIS...	YOU MAY NOT NEED THIS...
Ammonia[a] and soap	Glass wax
Chlorine[a] bleach	Disinfectant cleaner Mildew-stain remover Mildew preventive Toilet bowl cleaner Tub and tile cleaner
Cooking oil	Nonstick cooking spray
Cornstarch	Laundry starch powder Carpet and rug shampoo Some stain removers
General purpose household cleaner (powder)	Floor polish remover Scouring powder Tub and tile cleaner Oven cleaner
Laundry detergent	Laundry presoak
Mineral oil	Some household oils Some rust preventive oils
Scouring powder	Stainless steel cleaner Aluminium cleaner
Soap and water	Some jewelry cleaner Plant insecticides Plastic cleaners Some stain removers
Steel wool scouring pads	Aluminium cleaner Some rust removers Stainless steel cleaner
Vinegar	Coffeepot cleaner Some stain removers
Washing soda	Detergent boosters Drain cleaners Household detergents Water softeners

a/ Note: Never mix ammonia and bleach, or get them near each other. The result is a deadly poisonous chloramine gas.

Table 28. HOUSEHOLD CLEANERS: CHEMICALS REVIEWED. The following chemical ingredients are reviewed in the Product Technical Information Tables 29-37, or in earlier tables as referenced.

I. AROMATIC/ALIPHATIC HYDROCARBONS -- Table 29

- A. Benzene
- B. Petroleum distillates (reviewed in Table 21)
- C. Toluene (reviewed in Table 21)
- D. VM&P Naphtha (reviewed in Table 21)

II. CHLORINATED HYDROCARBONS -- Table 30

- A. Carbon tetrachloride
- B. Perchloroethylene (reviewed in Table 21)
- C. Paradichlorobenzene
- D. 1,1,1-trichloroethane (reviewed in Table 21)

III. GLYCOLS -- Table 31

- A. Diethylene glycol
- B. Ethylene glycol (reviewed in Table 21)
- C. Triethylene glycol

IV. ACIDS/BASES - Table 32

- A. Calcium hypochlorite
- B. Hydrochloric acid
- C. Oxalic acid
- D. Potassium hydroxide
- E. Sodium hydroxide
- F. Sodium hypochlorite

V. SURFACTANTS -- Table 33

- A. Anionic
    - 1. linear alkyl benzene sulfonate (LAS)
    - 2. sodium dodecyl benzene sulfonate
    - 3. sodium lauryl glyceryl ether sulfonate
- B. Cationic (QACs)
    - 1. alkyl dimethyl benzyl ammonium
    - 2. alkyl dimethyl ethyl ammonium (not reviewed)
- C. Nonionic
    - 1. alkyl ethoxylate
    - 2. alkyl phenoxy polyethoxy ethanol

(continued)

Table 28. HOUSEHOLD CLEANERS: CHEMICALS REVIEWED. (Continued)

VI. BUILDERS (Detergents) -- Table 34

- A. Soluble chelates
  - 1. sodium tripolyphosphate
  - 2. trisodium phosphate
- B. Chelate precipitators
  - 1. sodium carbonate
  - 2. sodium metasilicate
  - 3. sodium bisulfate

VII. FUNGICIDES -- Table 35

- A. O-benzyl-para-chlorophenol
- B. 4-chloro-2-cyclo-pentyl phenol
- C. O-phenyl phenol

VIII. PROPELLANTS -- Table 36

- A. Dichlorodifluoromethane
- B. Isobutane
- C. Propane
- D. Trichlorotrifluoroethane

IX. OTHER -- Table 37

- A. Ammonia
- B. EDTA
- C. Pine oil

The resulting list of chemicals does not constitute a complete and exact formulation of what is found in these products. Inevitably there will be some discrepancies with current ingredients. Manufacturing processes change, and the manufacturer may change the chemical composition of his product without a change in the brand name. A certain household product, using the same brand name, may have different ingredients depending on where it was manufactured. The ingredients are constantly being changed according to recent technological breakthroughs or local changes in abundance of certain ingredients.

Manufacturers are constantly seeking to improve their product -- which is why the Poison Control Center must update every six months. Nevertheless, most of these chemicals are either of long standing and common use, or are chemically similar to any substitutes that could be used. Although by no means exhaustive, this review has tried to give a fairly complete picture of the type of chemicals found in cleaning products.

As with all these product tables, the following "keys" will help you to decipher the information in Tables 29-37:

- Superscripted numbers or numbers in parentheses at the end of the notation refer to the source of the information. These citations are listed at the end of the Tables on page 139. Complete references are at the end of the report (page 179).
- Unfamiliar terms and abbreviations can be found in Appendix C: Glossary of Terms and List of Abbreviations (page 213). Further discussion on chemical structure and terminology is in Appendix A (page 190). Appendix B (page 201) will help you to understand toxicity and the terms used to describe it.

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Table 29: ALIPHATIC AND AROMATIC HYDROCARBONS

	●Source of chemical ●Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Benzene	NO LONGER USED IN CONSUMER PRODUCTS! May be found in old dry cleaning fluids or spot removers.	Probably slight	Refer to listing for Benzene under "Automotive Products - Gasoline" on pp. 161 for toxicity ratings, human health hazards and environmental effects.			

Table 30: CHLORINATED HYDROCARBONS

	●Source of chemical ●Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Carbon tetrachloride	NO LONGER USED IN CONSUMER PRODUCTS! May be found in old dry cleaning fluids & spot removers.	Probably slight.	●PEL (air): 10 ppm TWA (65 mg/m^3) with ceiling 25 ppm NIOSH recommends ceiling 2 ppm IDLH - 300 ppm ●Concentration in water, to protect human health - preferably zero.. Additional lifetime cancer risk: 1:100,000 presented by concentration 4.0 ug/l (6)	●Carcinogenic (animal positive, IARC) (5) non-human mammals- causes liver & kidney damage, biochemical changes in liver function & neurological damage (5). ●mutagenic effects not observed, teratogenic effects suspected but not demonstrated (5) ●possibility of cutaneous absorption (6) ●hazard of systemic effects increased when used in conjunction w/ingested alcohol (6)	●Aquatic toxicity: LC_{50} 96 hr. - 27,300 - 125,000 ug/l (bluegill) (5) ●no adverse effect (fathead minnow) up to 3,400 ug/l (5) ●biological 1/2 life in bluegill less than 1 day(5) ●hazardouse substance (EPA) priority toxic pollutant (EPA) ●Incompatible with chemically active metals (6) ●concentration in water: freshwater - 35,200 ug/l (acute) saltwater - 50,000 ug/l (acute) (6).	Hazardous waste. (EPA)

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Table 30: CHLORINATED HYDROCARBONS (continued)

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Paradichlorobenzene	•Synonyms: PDB; para crystals; etc. •used in solid toilet bowl deodorizers, moth balls.		•irritant: -eye human 80 ppm (2) •toxic dose: -oral human LD_{LO}: 500 mg/kg (2) -oral human TD_{LO}: 300 mg/kg (toxic effect: systemic) (2) -oral rat LD_{50}: 500 mg/kg (2) -subcutaneous mouse LD_{50}: 5,145 mg/kg (2) •inhalation: -PEL (air): 75 ppm TWA (2) -TLV: 75 ppm (2)	•ingestion of 20 g. well tolerated in humans (1) •vapor irritating to skin eyes & throat (1) •no severe clinical poisoning from ingestion-large doses in animals ↔ liver injury & tremors (1) •selected by NCL for carcinogenisis bioassay 12/78; determination: indefinite (2).	Unknown.	

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Table 31: GLYCOLS

	●Source of chemical ●Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Diethylene glycol	Synonyms: glycol ether, glycol ethyl ether, etc. Found in: pre-wash spot and stain removers, window cleaners, disinfectants, floor cleaners, & waxes.	All window cleaners: 0.4 g/capita/ day (4) All floor polishes & finishes: 0.27 g/capita/ day (4)	●Probably lethal dose in man is 1000-2000 mg/kg (1). ●skin-human 112 mg/MILD (2) ●oral human toxic dose LD_{50}: 1000 mg/kg (2) ●oral rat LD_{50}: 14800 mg/kg ●subcutaneous mouse: LD_{LO}: 5000 mg/kg (2) ●toxicity by inhalation: 100 ppm (suggested) (10)	●Slightly less toxic than ethylene glycol. Causes CNS depression & degenerative lesions in liver & kidneys. (1)	●Aquatic toxicity rating: TL_m 96: > 1,000 ppm (2) ●Freshwater toxicity: TL_m 96 hour - > 32,000 ppm (mosquito fish) ●Combustible (10) ●dangerous to aquatic life in high concentrations (10)	
Triethylene glycol	●Found in disinfectants.	Unknown.	●Oral human: LD_{LO}: 5000 mg/kg (2) oral rat LD_{50}: 17,000 mg/kg (2) subcutaneous mouse: LD_{50}: 8750 mg/kg (2)	●Lower acute toxicity than diethylene glycol. symptoms are presumably like those due to ethylene glycol, but there is no evidence of decomposition to ethylene glycol in vivo (1) ●Very low acute and chronic toxicity (3)	●Aquatic toxicity rating: TL_m 96: over 1000 ppm (2) ●biological effects: -inhibition of all multiplication at: 320 mg/l - bacteria 3600 mg/l - algal (3) ●LD_{50} (24 hour) goldfish - > 5000 mg/l (3)	

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Table 32: ACIDS/BASES

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Sodium hydroxide	•synonyms: caustic soda; lye; sodium hydrate; NaOH •found in: oven cleaners; drain cleaners, bleaches	•all drain cleaners: 0.2 g/capita/day •all bleach (liquid & powder): 11.39 g/capita/day	•Concentrations in air: -PEL (air): 2 mg/m^3 (6) -NIOSH recommends ceiling 2.0 mg/m^3 for 15 min. (6) -IDLH: 200 mg/m^3 (6)	•alkaline and very corrosive •dermatitis may result from repeated exposure to dilute solutions (6) •local contact w/eyes, skin, throat results in extensive tissue damage → blindness, burns, etc. (6) •systemic effects due to local tissue injury (6)	•Hazardous substance (EPA) •corrosive (DOT) •incompatible with water, acids, flammable liquids, organic halogens, metals, nitromethane & nitro compounds (6) •no criteria in water for NaOH. Criteria for pH: -freshwater pH 6.5-9.0 -saltwater pH 6.5-8.5 -human health (drinking water): pH 5-9 (6)	Disposal recommendations: discharge into tank containing water, neutralize, then flush to sewer with water (6)
Potassium hydroxide	•synonyms: caustic potash; lye •found in: oven cleaners, drain cleaners, bleach	•all drain cleaners: 0.2 g/capita/day •all bleach (liquids & powder): 11.39 g/capita/day	•toxic dose: oral rat LD_{50}: 365 mg/kg (2) •TLV (air) 2 mg/m^3 (2) •see also ratings for sodium hydroxide	•corrosive poison see sodium hydroxide	•aquatic toxicant rating: TL_m 96: 100-10ppm (2) •corrosive (DOT)	

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Table 32: ACIDS/BASES (continued)

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Hydrochloric acid	•Synonyms: hydrogen chloride (gas), muriatic acid. Found in toilet bowl cleaners, drain cleaners.	Toilet bowl cleaners: 1.19 g/capita/day drain cleaners 0.2 g/capita/day	•PEL (air): 5 ppm ceiling value IDLH: 100 ppm (6) No oral doses.	•Highly corrosive to eyes, skin & mucous membranes - may produce burns, scarring on skin, blindness in eyes (6) •ingestion may be fatal due to esophageal or gastric necrosis (6) •vapors in respiratory tract may produce glottal edema, bronchitis, pulmonary edema & death.	•Nonflammable gas or, in aqueous solution, acid •incompatible with most metals, alkalis or active metals (6) May produce flammable gas. •aquatic toxicity - Freshwater: TL_m 96 hr - 282 ppm (mosquito fish) (10) Saltwater: LC_{50} 48 hr - 100-330 ppm (shrimp) (10) Dangerous to aquatic life in high concentrations. (10)	•Soda or ash slaked lime will neutralize.
Sodium hypochlorite (NaOCl)	•synonyms: Bleach; NaOCl •found in: disinfectants, bleaches, deodorizers drain cleaners	All Bleach (liquid & powder): 11.39 g/capita/day all Disinfectants: 0.3 g/capita/day all drain cleaners: 0.2	•toxic dose: -oral rat LD_{50}: 8.91 g/kg	•corrosive to skin, eyes & mucous membranes •harmful if swallowed (5) •lethality more related to concentration than to dose. Consumer solutions of 4-6% probably lethal to adults only in oral doses of many ounces (1)	•corrosive •harmful to aquatic life in very low concentrations- may be dangerous if enters water intakes (5) •may decompose in fire, generating chlorine gas (5) •all hypochlorite solutions are unstable--slowly decomposing on contact w/air, they become less toxic w/age (1)	Destroy with sodium bisulfite or hypo and water, then neutralize with soda ash (5).

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Table 32: ACIDS/BASES (continued)

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Calcium hypochlorite	•Found in toilet bowl cleaners, bathroom cleaners, bleach chlorine	Toilet Bowl Cleaners: 1.19 g/capita/day (4) liquid household cleaners 4.15 g/capita/day (4) bleach 9.92 g/capita/day (4)	See "sodium hypochlorite" listing for comparative toxicity ratings, human health hazards and environmental effects.			Never mix with anything other than soap & water. (7)
Oxalic acid	•Found in toilet bowl cleaners, dry cleaning fluids & spot removers.	Toilet Bowl cleaners: 1.19 g/capita/day (4) Others unknown.	•Severe acute effects (7) •PEL (air): 1 mg/m^3 (6) tentative STEL - 2 mg/m^3 IDLH - 500 mg/m^3 (6).	•Corrosion of mouth, esophagus & stomach, kidney & liver damage, irritation of eyes & upper respiratory tract. (7) •chronic skin irritant (7) inflammation of upper respiratory tract. (6).	•Incompatible w/strong oxidizers and silver (6). •no criteria set for concentration in water (6) •toxic gases may be released in fire (9)	

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Table 33: SURFACTANTS
A. Anionic Surfactants

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Linear alkyl benzene sulfonate	•synonyms: alkylate sulfonate: LAS. •the alkyl group, synthesized from petroleum, consists of 12-13 carbon atoms in straight-chain. •widely used in laundry & other household detergents, bathroom cleaners, rug cleaners, and all-purpose cleaners.	•all liquid household cleaners: 4.15 g/capita/day (4). •all liquid & automatic dishwashing detergent: 9.79 g/capita/day (4). •laundry detergent: 23.51 g/capita/day (4).	•toxic dose: -oral rat LD_{50}: 0.8-3 g/kg (1) 650 mg/kg (2)	•most commercial mixtures cause prompt emesis-amounts absorbed probably have no significant systemic toxicity (1) •at levels of 0.5 mg/day (for 2 weeks), caused liver ailments in mice when absorbed through skin. Equivalent dose for humans= 0.015 mg/kg at 0.1 solution (7).	•biodegradable (1) •without qdequate supply of oxygen (as in eutrophying water body); LAS can build up to lethal levels. (e.g., 1 mg/l for oysters). (7)	
Sodium Dodecyl Benzene Sulfonate	•synonyms: alkyl aryl sodium sulfonate; dodecyl benzene sodium sulfonate; sodium lauryl benzene sulfonate; ultrawet •found in laundry and other household detergents, bathroom cleaners, rug cleaners, all purpose cleaners.	See Linear alkyl benzene sulfonate.	•toxic dose: -oral rat LD_{50}: 1260 mg/kg (2) -oral mouse LD_{50}: 2000 mg/kg (2) -intravenous mouse LD_{50}: 105 mg/kg (2)	•prolonged skin contact may cause irritation. Sensitization or allergic reaction rare (1). •no systemic effects in rats in low level feeding experiments (1). •mechanism of death at high oral doses (acute) unknown (1).	Unknown.	

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Table 33: SURFACTANTS

A. Anionic Surfactants (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Sodium lauryl glyceryl ether sulfonate	•Synonyms: 3-dodecyloxy-2-hydroxy-1-propanethanol 1-(sodium sulfonate). •found in laundry and other household detergents, bathroom, rug and all-purpose cleaners.	See Linear alkyl benzene sulfonate.	•toxic dose: oral rat LD_{50}: 1.82 g/kg (1)	•feeding experiments on rats at levels of 0.5% for 2 yrs. produced no anatomical, biochemical or microscopic lesions (1) •no tumors from skin applications on rats (1).	Unknown.	

B. Cationic Surfactants

Alkyl dimethyl benzyl ammonium	•synonyms: Benzalkonium chloride; BTC. •probably not widely used cationic surfactant -use concentrations 0.1 % of less (1). •found in deodorizers, bacteriacides, sanitizers.	Unknown.	•irritant: -skin human 150 µg/3 days (2). mild irritant -eye rabbit 100 µg (2). •toxic dose: -oral human LD_{LO}: 50 mg/kg (2). -oral rat LD_{50}: 400 mg/kg (2). -interperitoneal mouse LD_{LO}:(0 mg/kg) (2). •probably oral lethal dose for humans 5-500 mg/kg (1). •toxicity depends on length of alkyl group (1).	•nature of toxic response varies with dose, concentration and rate of administration (1). •toxic effects: - primary skin & mucous membrane irritant (1) - ingestion causes burning pain, rapidly developing weakness and confusion, and CNS depression. A few cases of asphyxial death due to paralysis of respiratory muscles (1).	•Unknown.	•BTC reacts with soap and most proteins; therefore, it is maximally germicidal effective only on "chemically clean" surfaces (1).

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Table 33: SURFACTANTS

C. Nonionic Surfactants

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Alkyl ethoxylate	•found in air fresheners, dishwashing laundry detergent and bathroom cleaners.	•all dishwashing detergent: 9.79 g/capita/day all laundry detergents: 23.51 g/capita/day liquid household cleaner 4.15 g/capita/day.	•toxic dose: oral rat LD_{50}: 2.2-4.1 g/kg (1). oral mouse LD_{50}: 1.4-1.2 g/kg (2) otoxicity depends on length of alkyl chain.	•monkeys administered oral doses 2 g/kg exhibited emesis, diarrhea -single doses 5 g/kg cause CNS depression (1). •very toxic by interperitoneal injection (1)	Unknown.	
Alkyl phenoxy polyethoxy ethanol	•synonyms: Alkyl aryl polyether alcohol; Alkyl phenol polyglycol ether; polyethylene glycol alkyl aryl ether. •used as wetting agent and emulsifier in air fresheners, laundry and dishwashing detergents, bathroom cleaners.	See Alkyl ethoxylate.	•toxic dose: - oral human LD_{LO}: 5000 mg/kg (2). - interperitoneal mouse LD_{50}: 3100 mg/kg (2).	•rarely sensitizes or irritates skin even at full concentrations (1). •symptoms and lesions in orally poisoned animals related to GI irritation; little intestinal absorbtion or decomposition (1).	Unknown.	

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Table 34: BUILDERS (Detergents).
A. Soluble Chelates

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Trisodium phosphate	•synonyms: TSP, phosphoric acid, trisodium salt •found in: abrasive powders, dishwashing detergent, laundry detergents.	•all laundry detergents: 23.51 g/capita/day (4). •all dishwashing detergents: 9.79 g/capita/day (4). •all abrasive cleaners: 0.29 g/capita/day (4).	•irritant: skin rabbit 500 mg/24 hrs moderate irritant (2). •PEL (air): for phosphoric acid- 1 mg/m^3 TWA (9).	•aqueous solutions of TSP highly alkaline & may produce caustic burns. (1) •chlorinated TSP selected by NCl for carcinogenesis bioassay 12/78 (2).	•phosphates encourage algal growth, which results in depleted oxygen & in some cases, fish kills and eutrophication (7).	•total annual use of detergents is 25 million metric tons--which means annual use of phosphates of 1 million metric tons (8).
Sodium tripolyphosphate	Synonyms: STPP Triphosphoric acid, sodium salt; tripolyphosphate •Act as "builders" dishwashing detergents, laundry detergents, coffee cleaners.	All laundry detergents: 23.51 g/capita/day dishwashing detergent: 9.79 g/capita/day	•Oral human LD_{LO}: 500 mg/kg (2) oral rat LD_{50}: 6500 mg/kg (2) intravenous-mouse 74 mg/kg (2)	•Strong concentrations attack skin, eyes, lungs(7) •irritating due to alkalinity and hypertonicity; if ingested, nausea, vomiting & diarrhea probable (1)	•Phosphates encourage algal growth, which results in depleted oxygen, causing fish cells & eutrophication (7)	Total annual use of detergents 2.5 million metric tons, which equals about 1 million metric tons of phosphates (8)

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Table 34: BUILDERS (Detergents)

B. Chelate Precipitators

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Sodium bisulfate	•synonym: bisulfate of soda •used as a water softener--precipitates calcium from the water by acting as metal chelator •found in detergents	•all laundry detergents: 23.51 g/capita/day (4). • 11 dish-washing detergents 9.79g/capita/day. (4).	Unknown.	•corrosive to most bodily tissues. (1)	•aqueous solutions are strongly acid (1).	
Sodium carbonate	•synonyms: soda ash; disodium salt of carbonic acid. The technical decahydrate is known as sal soda or washing soda.	See sodium bisulfate.	•irritant: - skin rabbit 500mg/24hr. moderate irritant (2). - eye rabbit 100mg/24 hr. severe irritant (2). •toxic dose: - oral rat LD_{LO}: 4000 mg/kg (2) - interperitoneal mouse LD_{50}: 117 mg (kg)(2).	•as with other alkaline corrosives, the hazard is related more to concentration than to dose. Concentrated solutions can cause necrosis of mucous membranes (1).	Unknown.	
Sodium meta-silicate	•synonyms: disodium salt of silicic acid; electrosol dishwashing detergent, soluble glass. •found in phosphate-free and low-phosphate laundry and dishwasher detergent products (1)	See sodium bisulfate.	•toxic dose: -oral human LD_{LO}: 500 mg/kg (2). -oral dog LD_{LO}: 250 mg/kg (2). -intraperitoneal guinea pig LD_{LO}: 200 mg/kg (2).	•the most alkaline and corrosive substance in detergents--0.5% solution has pH of 12.5 (1). •dangerous on skin, eyes, all mucous membranes, not chronically toxic (1)	•more soluble and more caustic than sodium silicates (1).	

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Table 35: FUNGICIDES

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
O-phenyl-phenol	•synonyms: 2-biphenylol; sodium salt; Dowicide k; sodium salt of o-phenyl-phenol •found in disinfectants	•all disinfectants: 0.3 g/capita/day (4)	•irritant: -skin-human : 5 mg mild irritation effects (2) -skin rabbit: 25 mg mild irritation (2) •toxic dose: -oral rat LD_{50}: 1160 mg/kg (2)	•not absorbed in acutely toxic amounts thru skin (1) •aqueous solutions of sodium salt irritating on human skin in concentrations of > 0.5% (1) •eye irritant, may cause corneal injury (1) •in rats, oral lethal dose causes death by nervous depression in cats, oral doses in aqueous solutions cause hemorrhages in GI tract, liver, lung & myocardium (1)	•some heavy metal contribution to wastewater from disinfectants (4) •approximately 1.0 mg/l concentration causing adverse taste in fish	
O-benzyl-para-chloro-phenol	•synonyms: Santophen 1; o-cresol, 4-chloro-alpha-phenyl-; chlorophene •found in disinfectants and furniture polish; a germicide.	•all disinfectants: 0.3 g/capita/day (4) •all furniture polish: 0.7 g/capita/day (4)	•toxic dose: -oral human LD_{LO}: 500 mg/kg (2) -lower oral toxicity than phenol (1)	•primary skin irritant in formulations >10% •percutaneous absorption in rabbits (1) •only mild skin irritation after prolonged contact with use - dilutions (0.03%) •poisoned animals → diarrhea, rapid breathing, dyspnea, collapse, death (1)	•chlorinated phenols (general): -solubility in water low (5) -undergo photolysis in water → photodegradation also microbiol degradation (5) See Pentachlorophenol in Paint Products Technical Information, Table : Wood Preservatives.	

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Table 35: FUNGICIDES (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
4-chloro-2-cyclopentyl phenol	•synonyms: phenol, 4-chloro-2-cyclopentyl; Dowicide 9 •found in disinfectants; a germicide used on non-living species.	all disinfectants: 0.3 g/capita/day (4)	•irritant: -human skin: 25 mg mild irritant -eye rabbit: 100 mg severe irritant (2) •toxic dose: -oral rat LD_{LO}: 420 mg/kg (2) -skin rabbit LD_{50}: 850 mg/kg (2)	•concentrated material on skin may cause redness & moderate chemical burns(1 •in rabbit eye, causes eye inflammation & moderate to severe corneal injury (1) •vapors may cause lung irritation (1) •believed to resemble phenol in its systemic effects, e.g., penetrates skin rapidly → → CNS depression w/coma, respiratory arrest, cardiac or respiratory deaths (1)	•chlorinated phenols (general): •solubility in water low (5) •undergo photolysis in water → photodegradation also microbial (5) degradation See Pentachlorophenol in Paint Products Technical Information, Table : Wood Preservatives.	

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Table 36: PROPELLANTS

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Dichloro-difluoro-methane	•Used as propellent in aerosol products, especially in disinfectants, spray spot removers.	Unknown	•PEL (air) - 1000 ppm TWA (4950 mg/m^3) (9) Poor warning properties. (9)	•Short term exposure: dizziness, involuntary trembling, unconsciousness & death. May cause irregular heartbeat if liquid gets on skin or eyes, may cause frostbite. No cumulative or chronic toxic effects known. (9)	•Incompatible w/chemically active metals (Na, K, Ca, Al, Zn, Mg), •toxic gases may be released when decomposes (9). •aquatic toxicity TL_m 96: > 1,000 ppm (2) •evidence that causes depletion of ozone in upper atmosphere (7)	
Isobutane	Synonyms: 2-methyl-propane •Used as propellent in aerosol products, especially rug cleaners, air fresheners, furniture polish.	All furniture polish: 0.07 g/capita/day Otherwise, unknown.		•Vapor irritating to eyes (10)	•Flammable, very volatile •not harmful to aquatic life (10)	

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Table 36: PROPELLANTS (continued)

	●Source of chemical ●Found in	- Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Trichlorotrifluoroethane	●Synonyms: fluorocarbon 113, freon 113, TTE Used as propellent in aerosol products, especially rug cleaners & upholstery cleaners.	Unknown.	●PEL (air): 1,000 ppm ($7,600\ mg/m^3$) (6) ●IDLH: 4500 ppm (6) ●skin rabbit - 500 mg - MILD (2) ●oral rat LD_{LO} - 45 mg/kg (2) Poor warning properties. (9)	●Harmful effects - throat irritation, dermatitis, drowsiness (6) ●breathing high concentrations may cause heart to beat irregularly or to stop (9) ●Narcotic. (9)	●Incompatible with chemically active metals (6) ●no criteria set for water (6) ●believed to deplete ozone layer of atmosphere ●toxic gases and vapors may be released when decomposes.	
Propane	●used as propellent in aerosol products, especially air fresheners, furniture polish.	●all furniture polish: 0.07 g/capita/day (4) otherwise, unknown.	●PEL (air): 1,000 ppm ($1800\ mg/m^3$) (6) IDLH: 20,000 ppm (6)	●simple asphyxiant dizziness, disorientation, excitation, frostbite affects CNS (6); vapors are not irritating to mucous membranes (10)	●flammable ●incompatible w/strong oxidizers (6) ●no water criteria set, but EPA has suggested ambient goal 120,000 ug/l (6) ●not harmful to aquatic life (10).	

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Table 37: OTHER

	•Source of chemical •Found in	Consumption (1979)	Toxicity ratings *	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Ammonia	•Found in window cleaners, oven cleaners, all-purpose cleaners, floor cleaners & floor waxes.	All purpose cleaners 4.5 g/capita/day (4) floor polishes and finishes 0.27 g/capita/day (4) window cleaners 0.4 g/capita/day	•PEL (air) 50 ppm TWA (35 mg/m^3) (9) good warning properties (9) •skin rabbit 385 mg/moderate •inhalation human LC_{LO}: 200 ppm oral rat LD_{50} - 350 mg/kg (2)	•Vapor even at low concentrations extremely irritating to eyes (1), respiratory tract & skin (9). Exposure of eyes to high gas concentrations may produce severe damage & temporary blindness. •long-term exposure may cause chronic irritation of eyes & respiratory tract (9)	•Incompatible with: -strong alkalis (promote evolution of ammonia gas) -hypochlorite-containing bleach or any chlorine containing product (formation of chloramines) (1) -contact with strong oxidizers may cause fires & explosions (9) •aquatic toxicity TL_m 96: 10-1 ppm (2) 2.0 mg/l affects the self-purification of water bodies (3) harmful to aquatic life in very low concentrations (10) waterfowl toxicity: 120 ppm (10)	•Household ammonia ranges in concentration 5-10% (1)

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Table 37: OTHER (continued)

	Found in/Synonyms	Consumption	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Ethylene diamine tetracitic acid	•synonyms: EDTA; acetic acid, (ethylenedinitrilo) tetraedetic acid, tetrine acid, endiate, etc. •found in disinfectants, toilet bowl cleaners, rug & upholstery cleaners	•disinfectants: 0.3 g/capita/ day (4) •toilet cleaners: 1.19 g/capita/ day (4) rug/upholstery: unknown	•Toxic dose: -oral rat TD_{LO}: 8,000 mg/kg (2) •subcutaneous-rat: TD_{LO}: 3,000 mg/kg (2) •intraperitoneal-rat LD_{50}: 397 mg/kg (2) •disodium salt of this acid - oral mice LD_{50} 20mg/kg (1) •Toxicity by ingestion: LD_{50}: 5-15 g/kg (as sodium or calcium salt)	•teratogenic in rats •calcium-disodium salts of this acid used as drug to increase excretion of lead, other heavy metals (1) •irritating to skin & eyes (5)	•binds metal cations tightly & renders innocuous (1) •not flammable •effect of low concentrations on aquatic life is unknown •aquatic toxicity: 129 ppm/96 hr/ catfish/tapwater (5) •fouling to shoreline, may be dangerous if enters water intakes (5)	
Pine Oil	•Source: consists of mixture of terpene alcohols, plus terpene hydrocarbons, borneol & terpene ethers (1) •found in disinfectants	•All disinfectants: 0.3 g/capita/ day (4)	•Oral human LD_{LO}: 500 mg/kg (12)	•irritating to eyes & mucus membranes (1) •produces hemorrhagic gastritis •systemic effects: CNS depression w/hypothermia & respiratory failure (1)	•Combustible liquid (DOT) (12)	

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Citations for Tables 29-37, "Household Cleaners Technical Information"

1. Gosselin et al., 1976.
2. Lewis and Tatken, 1979.
3. Verschueren, 1977.
4. Gurnham et al., 1979.
5. U.S. EPA, 1980.
6. Sittig, 1981.
7. Fritsch, 1978.
8. Hodges, 1973.
9. Mackison et al., 1981.
10. U.S. Department of Transportation, 1978.

SECTION V

AUTOMOTIVE PRODUCTS

A. BACKGROUND INFORMATION

1. Definitions

Motor vehicle products can pose a great source of health and environmental problems. Since auto products include everything from cooling system additives to gas and oil to white-wall tire paints, compiling a thorough review of health hazards to the home user and environmental hazards to fish and wildlife is beyond the scope of this study. Therefore, this section deals only with the motor vehicle products that are likely to be encountered or used by most automobile operators. Many auto repairs that require technical know-how are performed by professional mechanics in commercial garages and are not considered here. However, as the cost of automotive products and mechanic's fees continue to rise, more and more auto owners are tackling the routine maintenance and simpler repairs at home. This presents additional environmental and health hazards because of the increased use, storage, and disposal of motor vehicle products around the home. This section will examine those products that are used repeatedly during a normal year's car operation including gasoline and its additives, motor oil, antifreeze, batteries, and brake and transmission fluids. Other common auto products found in the home include paints, restorers, detergents, cleaners, and finishes, but these items are similar to the products described in either the Paint Products (page 51) or Household Cleaners (page 103) sections and can be referred to through the general class information in those sections.

In general, many of the motor products used in the home or readily contacted by the auto user are fuels and lubricants. These are petroleum products or "distillates" distilled from crude petroleum and chemically treated with additives to achieve the desired effect. An analysis of these processes from the chemical point of view can be found in Appendix A. When we refer to "oil" we are specifically referring to those fractions of petroleum that are used in automobile crankcases for lubrication. This should not be confused with heating oil, machine oil, or any of the various other fractions. The terms "automotive oil," "motor oil," "lubricating oil" or "lube oil" and "crankcase oil" are all synonymous and are used interchangeably in this text.

Automotive oil used by the individual or household is usually "virgin," meaning that it has been refined from base or crude petroleum stock. Often, additives are put into this virgin oil; for example, heavy metals, mono- and polycyclic aromatic hydrocarbons, halogenated hydrocarbons, phthalates, phosphates, phenols, amines and amine derivatives, detergents and dyes (see Table 46). In recent years, synthetic oils have also appeared on the market (e.g., "Mobil 1"). These are composed of polymer chains with phosphate esters at the ends, and are, for all intents and purposes, identical in use to virgin oil. Re-refined motor oil is used oil that has been treated with heat, pressure and chemicals to the point where it is usable again as an automotive lubricant. (Some used oils are only "reprocessed" or "recycled" for the removal of water and some solids, and then sold for heating fuels, road oiling and surfacing materials, wood preservatives and "fire logs.")

Gasoline requires little introduction other than a glance at the local service station dispensers labeled regular, unleaded, premium anti-knock, and so on. Gasoline is composed of hydrocarbons derived from crude petroleum which is distilled to achieve the desired fuel properties for automotive combustion (that is, it is chemically modified and blended to increase the octane levels). The additives in gasoline are numerous: anti-knock agents like tetraethyl lead, ethylene dichloride and dibromide; anti-rust agents such as amines; anti-oxidants like alkylated phenols; metal deactivators; detergents; dyes; and de-icers.

Antifreeze is used in automobile radiators to prevent overheating or freeze ups. Typically the radiator is drained and the old antifreeze is allowed to run down the driveway and enter the storm drainage system. The major ingredient of antifreeze is ethylene glycol. There are also small concentrations (2-3 percent) of borate, phosphate, and silicate in some antifreezes which serve as rust inhibitors.

Brake fluid is composed primarily of glycol ethers, while transmission fluid is similar to motor oil in its hydrocarbon base. The major hazardous component of batteries is the sulfuric acid which is used as a medium for electrolytic exchange. Batteries also often contain lead.

2. Regulatory Framework

Several federal regulations impinge on the contents, use, labeling or disposal of automotive products, mainly gasoline and motor oil. To our knowledge, there are no specific regulations concerning antifreeze, batteries, or brake and transmission fluids.

The main regulation controlling gasoline is concerned with emissions. The Clean Air Act of 1970 targeted automobiles as a major source of air pollution and mandated that their emissions be reduced. The development of cleaner-burning engines and catalytic converters was the result, along with a shift to unleaded gasoline. While this has had a beneficial effect on air quality, the removal of lead from gasoline has necessitated a shift to other components, such as benzene and polycyclic hydrocarbons, which may be more toxic. As Fritsch (1978) points out, "One toxic material (lead) is being replaced by another which must be treated with equal caution."

Other regulations that affect gasoline include the federal Clean Water Act, which prohibits the discharge of gasoline (or any flammable substance) into water, and Metro Resolution #3374, which prohibits dumping of gasoline or other flammable/combustible substances into the sewers or storm drains.

A number of different regulations affect motor oil contents, use, disposal, and accidental spills. The recycling and reuse of oil affects many of these points, one key to which is re-refining. The re-refining oil industry has undergone a significant decline in past years. From 1960 to 1970, for example, the number of re-refiners in the U.S. declined from 150 to 49 (Fritsch, 1973). There have been several reasons for this decline, including the difficulty in removing waste oil deposits and additives, and the problem of acid sludge disposal. The Excise Tax Reduction Act of 1965 resulted in the loss of a tax advantage that the industry once had over virgin lube oil, putting it at an economic disadvantage.

In October 1980, Congress passed the Used Oil Recycling Act (PL 96-463), which amended RCRA to "further encourage the use of recycled oil." This act includes the following provisions:

- Removes the requirement that re-refined oil be labeled "previously used" (which had resulted in its inability to compete with virgin oil)';
- Provides that lubricating oil be labeled with the statement "Don't Pollute -- Conserve Resources; Return Used Oil to Collection Centers;"
- Eases the performance requirements of used oil for automobile engines; and
- Assists States with funding to establish waste oil recycling programs (to have been backed up with $5 million each for 1982 and 1983, funds which were never realized).

Waste oil has not been designated under RCRA as a hazardous waste, and if recycled is exempt from the hazardous waste handling provisions as a "recycled waste."

Indiscriminate dumping of waste oil is against both federal and state law. The Clean Water Act provides for a civil penalty of up to $5,000 for the discharge of a quantity of oil which may be harmful. The EPA defines a quantity "which may be harmful" as any discharge which will "cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines." One automobile's waste oil is more than enough to meet the definition of a "harmful quantity" under the regulations, as one pint of oil can produce a slick approximately one acre in size (Holland, N.D.).

In addition to the Clean Water Act, the federal Oil Pollution Act of 1961 (PL 87-167) and its regulations promulgated by the U.S. Department of Transportation/Coast Guard pertain to transportation and handling of oil on navigable waters. The EPA is responsible for those regulations pertaining to non-transportation related facilities (e.g., oil drilling, producing and refining sites).

In the state of Washington, RCW Chapter 90 Section 48 states, "It is unlawful for oil to enter waters of Washington State." Violators are subject to clean up liability, damages, and penalty up to $20,000. This regulation authorizes the Department of Ecology to regulate oil handling activities.

In both the 1981 and 1982 Washington legislative sessions, bills have been introduced to encourage oil recycling, based on a similar piece of legislation that Oregon passed in 1977. The proposals direct the Department of Ecology to conduct a public education program to inform the public of the needs for and benefits of oil recycling by establishing an information center and voluntary collection points. Retailers who sell more than 500 gallons of oil per year would be required to post signs informing the public of where, how and why to recycle used oil.

B. USE OF AUTOMOTIVE PRODUCTS

1. Volume Estimates

An estimate of the volumes of automotive products that are used and disposed of will be useful in gauging their potential damage to soil or waterways.

There are about 90 million cars in this country, and to keep them running, consumers must buy and use automotive products. The quantities of antifreeze and brake and transmission fluids used and sold are unknown. About 100 billion gallons of gasoline are consumed in the U.S. each year (Fritsch, 1978). No figures have been found to determine what volume of gasoline is actually thrown away as waste, but it is probably low.

Much more complete volume statistics are available for lubricating oil. Table 38 shows the amounts of lubricating oil which were sold in the U.S. and in Washington State in 1977. Although

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removal of lead from gasoline has necessitated a shift to other components, such as benzene and polycyclic hydrocarbons, which may be more toxic. As Fritsch (1978) points out, "One toxic material (lead) is being replaced by another which must be treated with equal caution."

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Much more complete volume statistics are available for lubricating oil. Table 38 shows the amounts of lubricating oil which were sold in the U.S. and in Washington State in 1977. Although these figures are dated, current consumption is probably not much different, in that the growth that was experienced in 1978 was probably offset by declines in 1979 and 1980 (Loftness, 1981).

Not all of the automotive oil sold goes to privately-owned passenger vehicles or home mechanics. Loftness (1981) goes through a detailed analysis of the factors at play in determining the volumes of oil sold in different markets. He determined that eight million gallons of lubricating oil are sold to do-it-yourselfers, and of that amount about 4.5 million gallons remains after use. This figure may be quite conservative.

Table 38. AUTOMOTIVE/INDUSTRIAL LUBE OIL SALES
FOR 1977 IN THE U.S. AND EXAMPLE STATES.
(Bureau of Census, in Loftness, 1981.)

Sales in 1,000 of Gallons	Automotive	Industrial	% Split
United States	1,252,967	1,346,700	48/52
California	124,439	93,551	57/43
New Jersey	31,271	74,354	30/70
Pennsylvania	48,375	122,054	32/68
Washington	22,061	8,694	72/28

By comparison, the Canadian-owned Mohawk Lubricants, Ltd., which collects and recycles waste oil in British Columbia (population about half of Washington's), claims that an estimated eight million gallons of used lubricating oil are discarded annually in B.C. (Price, 1982). This higher general rate is also supported by an earlier study by Dwinn (1969) which determined that six million gallons of oil were used in King, Pierce and Snohomish Counties alone. Of this, 3.5 million were disposed of in an unaccountable manner.

These figures reflect the EPA estimate that 50 percent of the automotive oil (and 30 percent of industrial oil) is not directly burned or consumed in use, but disposed of as waste in some way (E,S&T, 1972).

2. Routes into the Environment

Given that a large volume of used motor oil is wasted, both nationally and locally, how are individual homeowners responsible? Statistics vary as to the relative contribution of the do-it-yourself oil changer. According to Gottlieb (1981), about half the vehicle households in the U.S. do their own oil changes, while these household account for almost two-thirds of the motor oil consumed. Another source has stated that do-it-yourself oil changers purchase 47 percent of the lube oil stock (Price, 1980). In a survey conducted by Metro in the Seattle/King County area (see Part C of this series), 46 percent of respondents said they change their own oil.

Furthermore, each individual oil changer deals with a significant quantity of oil. A survey performed in Oregon found that over half the respondents consumed between 11 and 30 quarts per year (see Table 39).

Table 39. ANNUAL CONSUMPTION OF LUBE OIL
BY PEOPLE WHO CHANGE THEIR OWN.
(Geyer and Glendening, 1979.)

Quarts/Year	# Responses	Percent
1-10	32	9.7
11-20	99	30.1
21-30	71	21.6
31-40	40	12.2
41-50	35	10.6
51-60	33	10.0
61-70	3	0.9
71-80	4	1.2
81-90	3	0.9
91+	9	2.7
	329	99.9

a. Direct Dump. How does the do-it-yourself oil changer dispose of his significant quantities of oil? Table 40 presents the results of two separate surveys, one done in 1973 by the EPA, the other done in 1978 and 1979 in Portland and three other cities by Oregon's department of Environmental Quality. Their results are surprisingly consistent in showing that the most common method of oil disposal is dumping it in the backyard. The Oregon study (Geyer and Glendening, 1979) found that 74 percent of those responding disposed of their oil directly into the environment, or about 4.4 million gallons each year.

Table 40. MEANS OF DISPOSING OF USED OIL.
Disposal by the Do-It-Yourselfer.

	EPA (1973)		Oregon 1977-8[a]	
Means of Disposal	Absolute Frequency	Relative Frequency	Absolute Frequency	Relative Frequency
Dump in backyard or elsewhere on property	157	33.6%	86	26.3%
Take to service station	73	15.6%	36	11.0%
Take to public dump	54	11.6%	14	4.3%
Dump in storm sewer	53	11.4%	6	1.8%
Dump in garbage can	50	10.7%	40	12.2%
Dump in empty lot	16	3.4%	12	3.7%
Pour down toilet	4	0.9%	1	0.3%
Sell	3	0.6%	4	1/2%
Pour down sink	2	0.4%	--	--
Use around the house	3	0.6%	--	--
Dust control	--	--	71	21.7%
Weed control	--	--	12	3.7%
Burn in incinerator	--	--	10	3.1%
Coat logs/fence posts	--	--	8	2.4%
Take to recycling center	--	--	7	2.1%
Other	52	11.2%	20	6.2%
	467	100%	327	100%

[a] Geyer and Glendening (1979)

b. Road Oiling. The second most common disposal method in the Oregon study was dust control, or road oiling. A 1974 EPA study (as quoted in Geyer and Glendening, 1979) found that only one percent of the oil used for road dusting remains on the surface of the road; 25-30 percent is lost to biodegradation, adherence to vehicles, and volatilization. With 70-75 percent being removed through runoff and dust transport, this constitutes almost a direct discharge. In areas where rainfall is low, this would be less of a problem than in high rainfall sites.

C. ENVIRONMENTAL IMPACT

1. Petroleum Products

The fate and impact of petroleum products (including automotive oil, gasoline, and transmission fluid) in the environment are difficult to characterize for a number of reasons. Petroleum products are a complex mixture of various petroleum hydrocarbons, additives and contaminants with varying physical, chemical and toxicological properties (see Tables 46 and 47). Furthermore, their exact chemical components, and therefore their levels of toxicity, are variable with their place of origin: Pennsylvania crude oil is substantially different from California crude, for example.

Why are petroleum products considered a hazardous substance in the home? Although they are toxic by ingestion and sometimes contain compounds with long-term human health effects, they are primarily hazardous as environmental pollutants. For one thing, it is more likely that the unaware consumer would dump his used motor oil in the storm sewer or stream rather than ingest it, so the exposure is primarily environmental. In addition, petroleum products have certain properties which make them of particular hazard in one of two ways: a) physical, or b) toxicological.

a. Physical Effects. Petroleum hydrocarbons are stable in water, and may be found in any one of four levels in the aquatic environment: (1) coating the surface with a thin film, (2) emulsified in the water column, (3) in solution, or (4) settled on the bottom as sludge (U.S. EPA, 1976). The level that they are found in depends on the particular qualities of the product and the receiving water, as well as the amount of time they have been in contact with the water.

Surface films can coat and destroy plankton, algae and aquatic insects (Geyer and Glendening, 1979), and kill waterfowl through loss of buoyancy, hypothermia (reduced natural insulation effectiveness), ingestion of toxic additives or contaminants through preening, and by decreasing mobility, thereby causing starvation or increased vulnerability to predators. These slicks also produce adverse aesthetic effects on fouled shorelines and beaches

(U.S. EPA, 1976). The coating and emulsifying properties can kill fish as well, by smothering the gill filaments and thus preventing respiration, or by increasing the biochemical oxygen demand and thus lowering dissolved oxygen levels (U.S. EPA, 1976). Finally, the presence of these oils as sludge on the bottom can asphyxiate benthic life forms.

Aquatic organisms use natural organic compounds to convey information about the environment. According to Geyer and Glendening (1979), very small quantites of petroleum hydrocarbons can interfere with these natural "information" compounds. They quote a 1974 EPA study which found that 0.9 ml oil in 100 ml sea water caused noxious odors in a lobster's environment and subsequent irregular feeding patterns. All of the above are examples of the physical effects of petroleum hydrocarbons in the environment.

b. Toxicological Effects. The toxicological hazards of petroleum products consist of both acute lethal and long-term sublethal toxicities to aquatic organisms (U.S. EPA, 1976). Large-scale oil and gasoline spills have caused widespread, immediate death to aquatic organisms (e.g., the Tampico Marine spill (1957), the West Falmouth, Massachusetts spill (1969)). Marine larvae appear to be the most sensitive life stages, reacting to concentrations as low as 0.1 mg/l (U.S. EPA, 1976).

The long-term, low level effects of oil pollution consist of interference with the cellular and physiological processes, such as feeding and reproduction, rather than instant death (U.S. EPA, 1976). This can occur even at very low concentrations (10-100 ug/l). Waste oil contains polycyclic aromatic hydrocarbons (PAHs), some of which are carcinogenic; these compounds are found in higher concentrations in used rather than virgin oil (U.S. EPA, 1977). Table 41 lists some common components of motor oil and their toxicities; some of these (xylene, toluene, lead, zinc, benzene) are reviewed elsewhere in this text.

Other problems associated with long-term, sublethal exposure to petroleum products include bioaccumulation in organisms and accumulation in sediments. These are of some concern from a public health standpoint for edible species, especially in that some edible marine organisms may incorporate the carcinogenic PAHs into their tissue (U.S. EPA, 1976). In addition, the accumulation of these compounds in the sediments as well as the species could have long-term effects on the entire benthic community.

In addition to the petroleum-based chemicals, automotive oil, gasoline and transmission fluid also contain additives which increase their toxicity. Motor oil additives include tricresyl phosphate (TCP) (see Table 47), which Fritsch (1978) identified as a "motor oil additive of major health concern" due to widespread poisonings caused by this chemical (although its aquatic toxicity is actually quite low). A host of additives are used

Table 41. TOXICITY OF SOME COMPOUNDS FOUND IN WASTE OIL. All figures are "toxic dose"; the type of toxicity (e.g., liver damage, cancer, neoplasm) may vary. See Appendix B for background and keys to exposure and dosage shorthand. (From NIOSH, 1973, as quoted in Geyer and Glendening, 1979.)

Napthalene		
	orl-rat	LD50 - 2200 mg/Kg
	ipr-mus	LDLo - 150 mg/Kg
Xylene		
	ihl-hmn	TCLo - 200 ppm
	orl-rat	LD50 - 4300 mg/Kg
Toluene		
	ihl-hmn	TCLo - 500 ppm
	orl-rat	LD50 - 3000 mg/Kg
	ipr-rat	LD50 - 1640 mg/Kg
Phenanthrene		
	orl-mus	LD50 - 700 mg/Kg
	skn-mus	TDLo - 2160 mg/Kg
Benzene, Ethyl		
	ocu-hmn	TDLo - 200 ppm
	orl-rat	LD50 - 3500 mg/Kg
Benzene, Propyl		
	orl-rat	LD50 - 4830 mg/Kg
Cadmium as chloride		
	orl-rat	LD50 - 88 mg/Kg
	scu-rat	TDLo - 2.2 mg/Kg
Lead as chloride		
	orl-gpg	LDLo - 2000 mg/Kg
Zinc as chloride		
	ivn-rat	LDLO - 75 mg/Kg
	per-ckn	TDLo - 1 mg/Kg

with gasoline, including (from Fritsch, 1978):

- Scavengers (such as ethylene dibromide (EDB) and ethylene dichloride) which can have extreme long-term human health effects, including cancer (see Table 47);
- Anti-knock agents (such as tetraethyl lead, tetramethyl lead) which can be fatal if ingested or absorbed in small amounts;
- Dyes, including one called DAB which is a "highly selective carcinogen inducing tumors in the livers of rats" (Fritsch, 1978);
- Anti-oxidants (amines or alkylated phenols) which may cause burns and skin irritation; and
- Anti-rust agents (fatty acid amines, sulfonates, alkyl phosphates), metal deactivators (amine derivatives), deposit modifiers (organic phosphorous compounds), de-icers (alcohols, glycols, formamides), and detergents.

Furthermore, as Table 41 shows, waste oil picks up heavy metals as contaminants from engine wear and combustion. About 3.4 million pounds of barium, 4.2 million pounds of zinc, 59 million pounds of lead and 21 million pounds of phosphorus compounds are estimated to enter the environment each year from combustion of gasoline (Fritsch, 1973). Fritsch concludes that the phosphorous compounds (such as tricresyl phosphate, which is reviewed here) are the biggest worry. Another source (Gottleib, 1981) states that the following are all found as additives in motor oil: nitrogen, sulfur, calcium, zinc, phosphorous, magnesium, barium, potassium and sodium. Also, according to Gottlieb (1981), iron, copper, silicon, chromium, tin and maganese are all picked up from engine wear. Finally, Yates _et al_. (1978) claim practically every metal can be found in used motor oil, as shown in the listing in Table 42.

Given the immense volumes of automotive oil and gasoline which are used every year, and the physical and toxic effects that they can cause in the environment, petroleum products from residential sources may present a significant source of environmental contamination.

2. Other Automotive Products

Much less is known about the environmental impact of non-petroleum based automotive products. Both antifreeze and brake fluids are based on glycols, which appear to be relatively benign in the environment. _Ethylene glycol_, the major component of antifreeze, is not particularly toxic to aquatic organisms (LC 50:100 ppm),

Table 42. TRACE ELEMENT COMPONENTS OF WASTE OIL. Concentrations are given in parts per million (ppm). (Yates et al., 1978.)

Element	Residual Oil (ppm)	Waste Oil (ppm)	
		Mean	Max.
Sulfur	920	0.44	1.40
Silver	20	0.10	0.60
Sodium	17.5	46.6	400
Zinc	0.8	219	5000
Copper	25	58.3	1160
Aluminum	--	67.1	2000
Barium	8	59.7	550
Nickel	120	6.4	44
Chromium	6	7.9	45
Calcium	24	316	6400
Iron	15	333	5100
Silicon	--	104	2500
Tin	3	12.5	140
Lead	10	125	2000
Phosphorus	40	307	2500
Boron	0.02	7.3	120
Magnesium	5	49.4	1000
Vanadium	1800	5.2	19
Molybdenum	0.05	2.2	19
Manganese	0.5	21.0	250
Cadmium	2	2.7	21
Titanium	--	6.5	110

although it is acutely toxic to mammals -- which is why so many pets are killed by this sweet-tasting poison. Sometimes increased oxygen demands in the aquatic environment can occur from addition of ethylene glycol, but this is generally offset by normal water aeration conditions. The problem with antifreeze does not appear to occur in the "virgin" or unused product, but rather in the used product, which can often be contaminated by heavy metals from engine blocks. Table 43 shows analyses of antifreeze for metal content.

Table 43. HEAVY METAL CONTENT OF ANTIFREEZE.
Previously unpublished data are concentrations in parts per million (ppm), from Metro (Carveth, 1981).

Metal	Vehicle #1	Vehicle #2	Vehicle #3	Vehicle #4
Cadmium	<0.006	<0.006	<0.006	<0.006
Chromium	0.22	0.08	0.02	<0.02
Copper	6.13	0.37	1.4	0.3
Nickel	0.13	0.17	0.08	0.09
Lead	2.97	0.41	0.78	0.34
Zinc	3.65	0.335	0.198	0.379

Vehicle #1	1971 Dodge Van with 91,600 miles
Vehicle #2	1975 Dodge Pickup with 36,000 miles
Vehicle #3	1980 Chevrolet Van with 3,500 miles
Vehicle #4	1981 Datsun Pickup with 1,700 miles

Most car batteries use sulfuric acid as the medium for electrolytic exchange. Sulfuric acid is completely water-soluble; in fact, it has an affinity for water which can cause explosive reactions. This can result in hazardous effects to the user if a leak occurs, but no long-term environmental damage, because dilution quickly reduces the acidic effects. Batteries may sometimes contain lead, and this can pose a human health hazard as well as be persistent in the environment.

D. ADDITIONAL COMMENTS

1. Disposal Means -- Pros and Cons

In a previous section we examined the methods commonly used to dispose of motor oil, and determined that most oil changers either directly dump their used oil on their property, or indirectly dump it via road oiling. As can be seen in the environmental impacts section, such actions will have a significant deleterious effect on wildlife, soil or the aquatic environment.

What are the alternatives? Another common procedure is to dispose of waste oil in the garbage can. Depending on the security of the landfill that receives it, the waste oil may or may not enter the natural environment in a harmful way. This disposal method is wasteful, however, from economic and energy conservation standpoints, because oil is a recyclable, reusable material.

The other and best means of disposal is to take used oil to a service station or recycling center. In those areas where re-refining facilities are available, this reuse is the preferred means from an environmental standpoint. Unfortunately, Washington State has no re-refining at this time, and the majority of waste oil is reprocessed and burned as fuel. This is more economical at the moment than re-refining, but pollutants, particularly lead, other heavy metals and polycyclic aromatic hydrocarbons (PAHs), are released in significant quantities into the air through this method. About 50 percent of the lead in waste oil is emitted in the stack gas when it is burned (Brinkman et al., 1981). The particular threat from lead may be diminishing, as lead is eliminated as a gasoline additive. Lead is not the only contaminant, however, and other toxic metals and PAHs are released as well during combustion. Even more hazardous emissions would result if substances such as pentachlorophenol or PCBs are mixed (improperly, and, in the case of PCBs, illegally) with the waste lube oil. Such practices, we hear, are not uncommon.

The standard procedure to overcome the general contaminant problem is to dilute the waste oil with virgin oil to the point where emissions of contaminants meet local air quality standards. This solution does not address the issues of total air emissions or ultimate disposal of the contaminants (as well as the economics of a wasted resource).

It appears, however, that a switch to the economically and environmentally desirable means of disposal -- re-refining -- will not be possible without government assistance or incentives. A restriction on burning waste oil has been suggested as a means to eliminate the competitive advantage of reprocessing over re-refining, by adding on the "cost" of pollution and waste. Such a restriction would have to be implemented gradually, however, to prevent a chaotic situation and the increased possibility of complete waste of used oil through dumping. An alternative to balance the economics or even favor re-refining would be some form of tax incentive. In addition, the U.S. Department of Energy could encourage establishment of re-refineries (the capital-

Table 44. COMPARISON OF ENERGY SAVINGS FOR VARIOUS USED OIL UTILIZATION METHODS RELATIVE TO DISPOSAL BY DUMPING. (Mascetti and White, 1978.)

Method and Process	Process Parameters			Energy Savings, Btu/gal used oil	Status of Operations
	Yield, % used oil	Energy Btu/gal used oil	Confidence Level*		
Burning					
Without pretreatment for contaminant removal	89[a]	0	HIGH	131,210	Common Practice
With pretreatment for contaminant removal	84	7,860	MED[b]	116,160	Not in Use
Re-refining					
Acid-Clay	65	7,660	HIGH	122,960	Extensive Commercial
Clay	60	7.160	MED	113,850	Limited Commercial
Caustic-Clay	62[c]	10,640	MED	135,900	Limited Commercial

(continued)

Table 44. COMPARISON OF ENERGY SAVINGS FOR VARIOUS USED OIL UTILIZATION METHODS RELATIVE TO DISPOSAL BY DUMPING. (Continued)

Method and Process	Process Parameters			Energy Savings, Btu/gal used oil	Status of Operations
	Yield, % used oil	Energy Btu/gal used oil	Confidence Level*		
Re-refining (Continued)					
Propane Extraction	70	22,570	LOW(d)	116,900	Limited Commercial in Europe
	82	23,550	LOW(d)	138,980	Limited Commercial in Europe
Distillation-Hydrotreating	76	9,820	LOW(e)	141,870	Pilot in Construction
BERC Colvent	71	23,150	MED	118,210	Pilot Plant
MZF Solvent	76	18,700	LOW(e)	132,520	Laboratory Glassware

(a) Represents lube oil content of used oil.
(b) For a medium level of pretreatment using solvent extraction process.
(c) Process also produces 16 percent fuel oil.
(d) Conflicting yield data reported.
(e) Inadequate data to substantiate yields.
* Degree of confidence in the reported process parameters.

intensive step) by pilot or incentive grants. Promotion of increased recycling by private citizens would aid such efforts by providing a stable, increased source of the used oil material, possibly at a lower unit cost.

In the past, re-refining also had serious environmental drawbacks. The most common re-refining process used to be (and still is, in some areas) acid-clay. Two separate wastes, the spent clay, which mainly contained hydrocarbons, and the acid sludge, which consisted of acid, lube oil, polymers, asphalt organics and other residues mixed with some healthy doses of heavy metals, are produced (Geyer and Glendening, 1979). The resulting wastes are hazardous, and their disposal methods not always environmentally sound. Other alternatives which do not produce hazardous wastes, such as solvent treatment/distillation (see Table 44), are now available.

Given the current situation in this state, however, the conscientious consumer is faced with the following disposal decisions:

- Dump directly on the ground or use to oil roads, kill weeds, etc. -- results in contamination of aquatic system, environmental damage, economic waste;
- "Recycle," i.e., have reprocessed and use as fuel -- releases lead and other contaminants into the atmosphere;
- Put in landfill -- may not be sealed off from leaching, economic and energy resource waste.

2. Energy Costs

While the environmental effects have been our primary concern in this study, the manner in which oil is used and disposed of has impacts on the energy resources of the region and country as well. Burning and re-refining are the two "disposal" methods which provide some energy gains. Table 44 provides a comparison between these two methods. Although burning provides high energy savings (Btu/gal used oil), it may not be the best method in terms of total energy costs. Burning of waste oil destroys high-quality basestocks which must then be replaced, using expensive (both in terms of money and environmental impact) extraction and production processes (Brinkman et al., 1981). This need for high quality lube oils will persist, even in the face of decreasing overall demand for oil.

Brinkman et al. (1981) provide an excellent analysis of the energy costs and economics of re-refining used oil. Their conclusion is:

> **Based upon the estimated demand for automotive lubricating oil basestock in America for 1980 of 1.178 billion gallons, about 648 million gallons of used oil would be generated. The production of 544 million gallons of lube oil basestock by the BETC re-refining process would decrease the output requirement of virgin-derived lube oil basestocks by nearly half from 1.178 billion to 634 million gallons. In terms of resource conservation, re-refining would conserve 43 to 76 trillion Btu's per year. The annual advantage for converting used lube oils to reusable oil rather than destroying it as a burner fuel supplement is the equivalent of 7 to 12 million barrels of imported crude oil per year. The value of such a saving to the nation at the current rate of $33 per barrel would be 237 to 400 million dollars annually.**

E. INFORMATION ON AUTOMOTIVE PRODUCT CHEMICALS

1. Study Method

Unlike the other consumer product classes reviewed in this study, automotive products did not require extensive investigation into current ingredients or labeling. The contents of lubricating oil, gasoline, antifreeze and the rest are well known and usually stable. Table 45 outlines those chemicals which are reviewed in Tables 46 through 48. The exceptions to the above are the additives and contaminants. Different sources will present conflicting reports of what can be found in automotive products.

As mention earlier in this chapter, gasoline contains a wide range of additives. Table 46 reviews the following chemicals: amines and amine derivatives, ethylene dibromide and ethylene dichloride, organic phosphorous and tetraethyl lead. Fritsch (1978) also lists a variety of other materials, such as fatty acid amines, sulfonates, alcohols, glycols, detergents and dyes, which are added to gasoline. Without more specific chemical identifications, and with no sure knowledge as to the extent of their use, they were not reviewed in detail.

Also, as mentioned earlier, different sources mention different heavy metals as being present in waste motor oil. Rather than attempt to review every one of these trace elements, we chose instead just two: lead as the contaminant most frequently cited as being of concern, and barium as an example of some of the other heavy metal contaminants.

Table 45. AUTOMOTIVE PRODUCTS REVIEWED

The following substances are reviewed in the "Automotive Product Technical Information" Tables 46 and 47 or in earlier tables or text, as referenced.

I. Gasoline -- Table 46
   - A. Petroleum hydrocarbons
     1. Benzene
     2. Toluene and Xylene -- see Table 21(B)
   - B. Additives
     1. Amines and Amine derivatives
     2. Ethylene dibromide
     3. Ethylene dichloride
     4. Organic phosphorous compounds
     5. Tetraethyl lead

II. Lubricating Oil -- Table 47
   - A. Petroleum hydrocarbons -- see Tables 46, 21 and text
   - B. Additives
     1. Tricresyl phosphate
   - C. Contaminants
     1. Barium
     2. Lead
     3. Chromium -- see Chromate Salts, Table 20(B)
     4. Others -- see text

III. Antifreeze
   - A. Ethylene Glycol -- see Table 21(D)

IV. Brake and Transmission Fluids
   - A. Brake fluid
     1. Propylene glycol -- see Table 21(D)
     2. Heavy metal contaminants -- see text
   - B. Transmission fluid
     1. Petroleum hydrocarbons -- see Table 46
     2. Mineral oils -- see Appendix A

V. Batteries
   - A. Sulfuric acid -- see general information for Hydrochloric acid, Table 32

As with all the other tables on products' technical information, certain pieces of information may be helpful in interpreting Tables 46 through 48:

- Many of the toxic exposure limits (e.g., PEL -- permissible exposure limit for air) are based on occupational exposure and are set low enough so that nearly constant exposure will not result in significant harm to the worker. Exposure in the home would tend to be more sporadic under most conditions.

- Numbers in superscript or parentheses refer to the source from which the information was taken. A key to these sources can be found in the Citations section at the end of the Tables on page 171. Complete listings of these Citations are found in the References section at the end of the report on page 179.

- Abbreviations and unfamiliar terms can (usually) be found in Appendix C: List of Abbreviations and Glossary of Terms on pages 221 and 213, respectively.

The chemistry of these substances, particularly for petroleum hydrocarbons, can be confusing. We suggest reading Appendix A (A Quick-and-Dirty Organic Chemistry Lesson) on page 190 if you are unfamiliar with the classes and groupings of these chemicals. Toxicity ratings and determinations are explained at length in Appendix B, page 201.

AUTOMOTIVE PRODUCTS TECHNICAL INFORMATION

Table 46: GASOLINE

A. Petroleum Hydrocarbons

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Benzene	•synonyms: coal naphtha, benzol •antiknock fuel additive, and constituent of gasoline	•inhalation: -PEL (air): has been subject to controversy -1974: 10ppm TWA w/ceiling 25 ppm -1977: emergency standard 1 ppm TWA with 5 ppm max peak for 15 min -1978: 1 ppm only in exempt workplaces, with restrictions. -1980: Supreme Court struck down because failed to show cost/benefit analysis (5) •concentration in water: to protect human health-preferably zero; additional lifetime cancer risk 1:100,000 at 6.6 ug/l (6).	•carcinogen (IARC) •Hazardous substance (EPA) •respiratory route = main exposure route (gasoline vapors, auto emissions) - accumulate in fat, bone marrow, liver tissue (5) •chronic exposure ↔ blood abnormalities -not mutagenic to bacteria -leukomogenic in humans (NAS/NRC) -may be teratogenic -may cause reduced fertility (5).	•Priority pollutant •acutely toxic to aquatic organisms in range 5,800 - 495,000 ug/l -marine fish (striped bass) most sensitive (5) •found in drinking water supplies at 0.1-0.3 ppb (5) •bioconcentration factor: 24 x •water criteria (AWC): -freshwater: 3,100 ug/l 24-hr avg., not to exceed 7,000 ug/l (5) -saltwater: 920 ug/l 24-hr avg., not to exceed 2,100 ug/l (5)	•Hazardous waste (EPA) •increased content in gas due to requirements for unleaded fuels (catalytic converted).

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Table 46: GASOLINE (con't)

B. Additives

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Amine and amine derivatives	•added to gasoline for several effects: 1. antioxidants to keep gasoline from decomposing and forming resinous gums. 2. anti-rust agents to keep small amounts of water from surface of metal containers. 3. metal deactivators to counter the oxidizing effect of small amounts of metals found in gasoline (7)	Unknown	•irritant and sensitizer (7) •amines usually form strong alkaline solutions - principal effect is alkaninization, or caustic effects (1) •liquid and vapor irritating to skin and mucous membranes (1) •in rats, pulmonary edema, liver necrosis and renal degeneration at high concentrations (1).	Unknown	

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AUTOMOTIVE PRODUCTS TECHNICAL INFORMATION

Table 46: GASOLINE (con't)

B. Additives (con't)

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations other comments
Ethylene dibromide	•synonyms: EDB; 1,2-dibromoethane; glycol bromide, etc. •added to leaded gasoline to work as "scavengers", removing lead oxides in the form of volatile lead halides (7)	•inhalation: -PEL (air): 20 ppm ($145\ mg/m^3$) TWA w/ceiling of 30 ppm (6) -NIOSH recommends limit 0.13 ppm ($1.0\ mg/m^3$) for 15 minutes (6) •irritant: -skin rabbit 1% 14 days severe irritant •toxic dose: -oral human LD_{LO}: 50 mg/kg (2) -oral rat LD_{50}: 108 mg/kg (2) -oral mouse LD_{LO}: 1800 mg/kg toxic effect: cancer	•positive carcinogen (NCI) in 1978, NCI called EDB "the most potent cancer-causing substance ever found in the animal test program at NCI" (6). •prolonged local contact with skin may cause blistering & skin ulcers-dermal sensitization. •vapor irritating to eyes, mucous membranes. •inhalation result in severe acute respiratory injury, CNS depression, vomiting, possible injury to liver & kidneys (6).	•Hazardous substance (EPA) •limited information suggests that EDB degrades at moderate rates in both water and soil (6). •incompatible with chemically active metals, and strong oxidizers (6). •no criteria set for concentration in water (AWC) (6). •aquatic toxicity rating: TL_m 96: 100-10 ppm (2)	•Hazardous waste (EPA) •increasing use of unleaded gasoline should result in lower ambient air levels of EDB (9 •Disposal recomme incineration wit adequate scrubbi & ash disposal (6).

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AUTOMOTIVE PRODUCTS TECHNICAL INFORMATION

Table 46: GASOLINE (con't)

B. Additives (con't)

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Ethylene dichloride	•synonyms: 1,2-dichloroethane; ethylene chloride; glycol dichloride, etc. •used as "scavenger" in gas, to remove lead oxides in the form of volatile lead halides, anti-knock agent.	•inhalation: -PEL (air): 50 ppm TWA w/ceiling 100 ppm and peak 200 ppm for 5 minutes (6). -NIOSH recommends: 5 ppm w/15 ppm ceiling (6). -neither standard provides protection from carcinogenic effects (6). -tentative STEL: 15 ppm -IDLH: 1,000 ppm (6). •irritant: -skin rabbit 625 mg mild irritant (2) -eye rabbit 63 mg severe irritant (2) •toxic dose: -inhalation human TC_{LO}: 4000 ppm toxic effect: cancer -oral rat LD_{50}: 12 ug/kg -oral human LD_{LO}: 428 mg/kg toxic effect: GI tract effects.	•severe irritant (7) •carcinogen (NCI, positive) •Hazardous substance (EPA) •inhalation of high concentrations may cause nausea, mental confusion, dizziness & pulmonary edema (6) can lead to death from circulatory & respiratory failure (6) •repeated long-term exposure results in neurologic changes, loss of appetite, irritation of mucous membranes, liver/kidney damage and death (6).	•Priority pollutant (EPA) •flammable •water criteria: -freshwater: 118,000 ug/l (acute) 20,000 ug/l (chronic) -saltwater: 113,000 ug/l (acute) -to protect human health: preferably 0 - additional lifetime cancer risk: 1:100,000 at 9.4 ug/l Level (6). •aquatic toxicity rating: TL_m 96: 1,000-100 ppm (2)	•Hazardous Waste (EPA) •Disposal recommendations: incinerate, preferably after mixing with another combustil fuel. Care must be taken to assure complete combustion, prevent formatior of phosgene gas. Use acid scrubber (6).

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AUTOMOTIVE PRODUCTS TECHNICAL INFORMATION

Table 46: GASOLINE (con't)

B. Additives (con't)

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Organic phosphorous compounds	•there are many organic phosphorous compounds, such as phosphorous oxychloride, phosphorous pentasulfide, & phosphorous trichloride. •used as a desposit modifier in gasoline, increasing the effective compression ratio (and causing engine knocking) (7).	for phosphorous oxychloride: •no federal inhalation standards, but ACGIH recommends 0.1 ppm (0.6 mg/m^3) TWA and STEL - 0.5 ppm (3.0 mg/m^3) (6) for phosphorous pentachloride: •toxic dose: -oral rat LD$_{50}$: 660 mg/kg (2) -inhalation rat LC$_{50}$: 205 mg/m^3 (2). •inhalation: -PEL (air): 1 mg/m^3 TWA (2) -ACGIH proposed 0.1 ppm TWA (6) -IDLH - 200 mg/m^3 (6)	for both phosphorous oxychloride and phosphorous pentachloride: •Hazardous substance (EPA) •skin, eye irritant phosphorous oxychloride: •skin burns and dizziness, anorexia, vomiting, chest pains, dyspnea, bronchitis, pulmonary edema (6) phosphorous pentachloride: •inhalation: acute pulmonary edema. chronic exposure→ bronchitis and pneumonia (6) •symptoms: convulsions, coma, photophobia, dizziness, irritability, GI distress (6).	•corrosive •no water criteria set for either PCl_5 or $POCl_3$; $POCl_3$ decomposes in water (6) •phosphorous pentachloride hydrolyzes to hydrogen sulfide in presence of moisture (6)	for oxychloride: •pour on to sodiu bicarbonate, spray w/aqueous ammonia, and add curshed ice. Neutralize and pour down drain for pentachloride: •decompose w/wate forming phosphori acid, sulfuric acid, and hydrog sulfide. Neutralize acids and discharge to sewer.

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Table 46: GASOLINE (con't)

B. Additives (con't)

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendation other comments
Tetraethyl lead	•synonym: TEL •added to gasoline as an anti-knock agent. It is a negative catalyst which prevents explosive combustion ("knocking")(7). •tetramethyl lead also used as anti-knock agent.	•inhalation: -PEL (air): 0.075 mg/m^3 (6) -tentative STEL: 0.3 mg/m^3 (6) -IDLH: 40 mg/m^3 (6) •toxic dose: -oral rat LD_{LO}: 17 mg/kg (2) -inhalation rat LC_{50}: 850 mg/m^3 for 60 minutes (2) -subcutaneous rabbit LD_{LO}: 32 mg/kg (2) •IARC carcinogenic determination: indefinite (2). Selected by NCI for carcinogenisis bioassay 12/78 (2).	•Hazardous substance (EPA) •ingestion or tactile intake of small amounts can be fatal (4). •may penetrate skin without producing local injury (6) •absorption of sufficient quantity of TEL, whether briefly at high rate or for prolonged periods at lower rate, causes acute intoxication of CNS (headache, nervous excitation, gastrointestinal symptoms). poisoning results in toxic delirium with hallucinations, convulsions, acute toxic psychosis (6).	•incompatible with strong oxidizers, sulfuryl chloride, potassium permanganate (6). •no water criteria (AWC) set, but EPA suggests ambient goal 1.4 ug/l (6). •will decompoase in bright sunlight to tri-, di-, and monoethyl lead compounds (6). •aquatic toxicity rating TL_m 96: < 1 ppm (2).	•Hazardous waste (EPA)

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Table 47: LUBRICATING OIL

B. Additives

(A. Petroleum Hydrocarbons -- see Tables 46, 21 and text.)

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Tricresyl phosphate	●synonyms: phosphoric acid, tritoyl ester; TCP; etc. ●used as gasoline and lubricating oil additives ●available as ortho-isomer (TOCP), meta-isomer (TMCP) and para-isome (TPCP). TOCP, discussed here as example, is most toxic (6).	●inhalation: -PEL (air): 0.1 mg/m^3 TWA (6) -IDLH: 40 mg/m^3 (6) ●irritant: -eye rabbit 500 mg/24 hr mild irritant (2) ●toxic dose: -oral rat LD$_{50}$: 4,860 mg/kg (2) -oral rabbit LD$_{LO}$: 100 mg/kg (2)	●high concentrations can cause paralysis (7) ●epidemics of poisoning due to ingestion via contaminated foodstuffs (6) ●major effect - spinal cord and peripheral nervous system (6) ●acute expsoure: GI distress, progressive muscle soreness & numbness (6) ●chronic exposure: long latent period → flacid paralysis of limb and leg muscles (6).	●no water criteria ●aquatic toxicity rating: TL$_m$ 96: 10-1 ppm (2) ●dangerous to aquatic life in low concentrations.	

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Table 47: LUBRICATING OIL (con't)

C. Contaminants

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations other comments
Barium compounds	•contaminant in automotive oil	•inhalation: -PEL (air): $0.5\ mg/m^3$ TWA -IDLH: $250\ mg/m^3$ (6) •concentration in water-domestic water supplies: 1.0 mg/l (EPA) (6).	•Hazardous substance •water-soluble barium compounds highly toxic to man (5) -small amounts can accumulate in bones (5). •dusts are eye, nose, throat irritants, cause baritosis (pneumoconiosis) (5). •barium salts strong muscle stimulator - acute exposure causes uncontrolled contractions, paralysis, cardiac disturbances (5)	•accumulates in fish and lower species of marine organisms (17,000 times in phytoplankton, 900 times in zooplankton) (5) •soluble concentrations must exceed 50 mg/l before toxic to aquatic life (5) •in natural waters, usually have sufficient sulfate and carbonate to precipitate barium as non-toxic compound (6)	•estimate 3.4 million pounds of barium dumpe (7) •Hazardous waste constituents (EPA)

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Table 47: LUBRICATING OIL (con't)

C. Contaminants (con't)

	Found in/Synonyms	Toxicity ratings	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments
Lead	•additive to gasoline, contaminant in crankcase lube oil •see also tetraethyl lead	•inhalation: -PEL (air): 1978 industry given 1-3 yrs to reach 0.1 mg/m^3 and 1-10 yrs to reach 0.05 mg/m^3 TWA -ACGIH: 0.15 mg/m^3 -STEL: 0.45 mg/m^3 •ambient airborne criteria: 1.5 ug/m^3 (EPA) 3 month average •water criteria (AWC): 50 ug/l	•Hazardous substance (EPA) (various compounds) •food=major source lead absorption (241 ug/day) (5). •affects blood circulation, causes neurological damage, irreversible renal damage, & adverse reproductive effects at high levels osuspected carcinogen (5)	•Priority pollutant (EPA) •ambient air: -metropolitan: 2-10 ug/m^3 -non-urban: 0.1 ug/m^3 (5) •toxicity to freshwater species dependent on (a) life stage of organism (b) water hardness LC_{50}(96) fathead minnow ranges from 7,480 ug/l (softwater) to 487,000 ug/l (hardwater) (5) •bioconcentrate in mussels 2,560 x ambient levels •found in high concentrations in drinking water (1,000 ug/l) (5).	•Hazardous waste constituent

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Table 48: BATTERIES

A. Sulfuric Acid

	•Source of chemical •Found in	Toxicity ratings*	Human health hazards	Physical Characteristics & Environmental Effects	Disposal Recommendations, other comments.
Sulfuric Acid	•used as electrolyte in batteries	•inhalation: -PEL (air): 1 mg/m^3 -IDLH: 80 mg/m^3 (6) •irritant: -eye rabbit 1380 ug. severe irritant (2) •toxic dose: -oral rat LD_{50} - 2140 mg/kg (2) -inhalation guinea pig - LC_{50} - 18 mg/m^3 (2)	•Hazardous substance (EPA) •burning of skin as result of strong exothermic reaction with water (6) •particularly harmful to mucous membranes and eyes (6) •single overexposure may lead to laryngeal or pulmonary edema (6)	•Soluble in water & alcohol •corrosive •incompatible with organics, chlorates, carbides, picrates, metals (6) •no criteria in water, but EPA recommends pH: -for freshwater aquatic life pH 6.5-9.0 -for saltwater aquatic life pH 6.5-8.5 -drinking water pH 5-9 (6)	

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Citations for Tables 46 and 47, "Automotive Products Technical Information"

1. Gosselin et al., 1976.
2. Lewis and Tatken, 1979.
3. Mackison et al., 1981.
4. Consumer Reports, 1977.
5. U.S. EPA, 1980b.
6. ittig, 1981.
7. Fritsch, 1978.
8. U.S. Department of Transportation, 1978.
9. U.S. EPA, 1975.

SECTION VI

CONCLUSIONS

A few findings are common to all four classes of toxic consumer products -- pesticides, paint products, household cleaners and automotive products -- which are reviewed in this document. In general, while toxic substances are widespread in consumer products, information on the specific constituent chemicals is often difficult or impossible to obtain. Determining the contents of familiar products is a challenge because of trade secret restrictions and because it is common for ingredients or proportions of ingredients to vary over time or geographical area. For example, a product used heavily in one region may be unavailable or of a slightly different composition in another region. Even when specific chemical constituents are known, however, information on chronic toxicities and environmental effects is patchy.

Another widespread and important data gap concerns information in quantities of products sold, used and discarded. In order to estimate the cumulative effect of numerous small, dispersed sources, knowledge of quantities is essential. Such estimates are difficult to determine for most product classes.

The labeling of products, whether for contents, directions for use, or recommendations for safe disposal, is often inadequate and sometime non-existent. Such labeling as "active ingredient: 0.5%, inert ingredients: 99.5%" can be misleading when the unnamed "inert" constituents are themselves toxic or hazardous. Lack of clearly defined contents hinders the consumer's ability to make buying choices. Recommendations such as "Dispose of in a safe manner" do little to assist the consumer in making proper disposal decisions.

In general, household products contain less toxic/hazardous substances than those chemicals used in commercial or industrial processes. Consumer products have tended in recent years to become safer or to contain smaller quantities or fewer kinds of the better-documented toxic chemicals, either in response to regulation, economics, (including increased costs of constituents and hazardous waste disposal), the market place, or liability concerns. As documented in the preceeding sections, however, toxic or hazardous constituents are common in household products and warrant concern in their disposal.

1. Pesticides

Household pesticides come in a wide variety of classes, including chlorinated hydrocarbons, carbamates, organophosphates and natural product extracts.

The types of pesticides classified for general use have changed in the past ten years; although many persistent chlorinated hydrocarbon pesticides (e.g., DDT) have been banned, there has been a tradeoff in use in that the faster-to-break-down pesticides (e.g., carbamates) often tend to be more acutely toxic.

An elaborate regulatory system for classification, review, labeling and use of household pesticides has been set up under FIFRA, but no equivalent system or recommendations have been established (under FIFRA, RCRA, TSCA or other laws) for disposal. The existing regulatory system for pesticides, while elaborate, is not useful or intelligible to the average citizen and is, in many ways, misleading.

Pesticides can enter the environment in a myriad of ways, by direct disposal, runoff, atmospheric processes, and accidental spills. Several factors influence the amount lost through runoff, including the pesticide's formulation, the site of application, and the time of application.

Very little is known about the interaction of pesticides with the environment under actual field conditions, especially effective long-term exposure on organisms and the fate of degradation products.

Conflicting and inadequate test data and a paucity of information on chronic effects make any ranking of pesticides by disposal hazard very difficult. However, it appears that certain classes such as the natural extracts (botanicals, synergists) have much less potential for environmental damage than some of the more powerful or persistent synthetic products.

2. Paint Products

Paints and paint-related items encompass a complex group of products including protective and decorative coating materials, solvents used with these coating materials and wood preservatives.

Paints can be classified as either solvent ("oil")-based or water-based, depending on their primary solvent. Solvent-based paints include enamels, varnishes, lacquers -- either natural lacquers, such as shellacs and gums, or synthetic lacquers, such as cellulosic resins -- primers, stains, seals and sealants, adhesives and specialty coatings. Water-based paints can be latex or watercolors. Different sheens in paint are designated as flat, semi-gloss, or gloss and can apply to either solvent-based or water-based paints. Latex paints have steadily replaced solvent-based coatings over the last twenty years; they now account for three-quarters of all "architectural coatings" manufactured in the U.S. (Connolly and Levine, 1980).

Paints as a class appear to pose relatively little potential for environmental harm through current proper disposal methods for two reasons:

- Paints usually don't contain chemicals with long-term effects, and
- Irresponsible use or disposal practices are probably rare.

Highly toxic pigments are less common in paints today, except for artists' paints, which still pose significant hazards to users (McCann, 1979). Other paint components such as the resins and fillers are stable and generally non-toxic.

Solvents are used both as components of paints (to allow the coating to be applied in liquid form) and as separate products for thinning or cleaning painting materials, furniture stripping and surface refinishing.

The solvents in "oil" paints and in separate solvent products are materials of concern. Many of them are acutely toxic to the user while some are suspected to pose chronic hazards such as liver and kidney damage (toluene, 1,1,1-tri-chloroethane) or cancer (perchloroethylene). The alcohols, ketones, esters and petroleum distillates tend to be less hazardous than the aromatic and chlorinated hydrocarbons. Care should be exercised with use and disposal of any organic solvent-containing product.

Wood preservatives, while generally considered to be paint products, are extremely toxic pesticides, and are usually resistant to breakdown under natural conditions. They are among the most hazardous products found in a household, both in terms of acute and chronic human toxicity and fate and effects in the environment. The constituents of greatest concern are the chlorinated phenols, especially pentachlorophenol.

3. Household Cleaners

Household cleaners comprise a range of cleaning and disinfecting products, such as disinfectants, bathroom cleaners, drain cleaners, furniture polish, dry cleaning fluid, bleach, oven cleaner, abrasive powder, air fresheners, floor cleaners and waxes, rug cleaners, upholstery cleaners and window cleaners, as well as laundry products such as detergents, fabric softeners and additives. This bewildering profusion of cleaners makes this class of products difficult to examine. Within each type of product, there are tens and sometimes hundreds of different formulations for specific uses and brands, and these formulations change over time and over geographical area. Unlike pesticides, cleaners do not consist of one easily identified chemical; rather, they are mixtures of complex and often unnamed synthetic compounds. Unlike paint products, information on cleaning chemicals is usually difficult to discover and inconclusive when found.

Cleaners often contain toxic or hazardous substances, but generally present more of an acute human toxicity concern through household use (which is widespread) than an environmental problem in disposal.

Labeling is generally inadequate for determining specific contents and/or their hazards (poor labeling seems to be more of a problem with cleaners than other product classes).

Organic solvent constituents seem to be of greatest concern, especially such disinfectants as chlorinated phenolics, and dry cleaning or septic tank/drainfield degreasing solvents such as 1,1,1-trichloroethane. They produce a wide range of serious chronic effects, and are suspected of being a source of groundwater contamination in some parts of the country.

Other specific household cleaning chemicals which may affect the environment through their disposal are:

- Chlorinated phenolics (little is known about their long-term effects);
- Detergents (used in enormous quantities); and
- Aerosol propellants (human health concerns, possible environmental effects).

Many of the household cleaners that are most acutely hazardous in their concentrated form are not a problem in the environment through normal use or disposal. This general statement is particularly true for the strong caustic (acidic or basic) products used as drain cleaners or clogged-drain openers, such as hydrochloric acid, sodium hydroxide and sodium hypochlorite. While presenting very high hazard to the user, once diluted in wastewater or the environment the constituents are benign and degrade rapidly.

4. Automotive Products

Motor vehicle products include such diverse items as gasoline, oil, cooling system additives, cleaners and polishes, paints, brake and transmission fluids and battery acid. Many of these products, specifically the fuels and lubricants, are fractions distilled from crude petroleum and chemically treated with additives.

About fifty percent of automotive oil is not directly burned or consumed in use, but is disposed of as waste in some way. Loftness (1981) estimates that eight million gallons of lubricating oil are sold to do-it-yourselfers in Washington State each year, and of that about 4.5 million remains after use. Dumping in a hole in the backyard is the most popular means of waste oil disposal.

Recycling of used motor oil is extremely convenient, as many full-service gas station will accept household quantities. Studies have shown, however, that while half of all households change their own oil, only 13 to 15% of those who change their own oil recycle it.

Petroleum products are primarily hazardous as environmental pollutants, with problems associated with their physical effects (coating surfaces, odor) as well as toxicological effects (both acute lethal and long-term sublethal). Some components of waste petroleum products can accumulate in sediments and bio-accumulate in organisms.

Most of the motor oil recycled in King County is burned as a fuel, raising an air quality concern; re-refining for re-use as a lubricant would be preferred.

Gasoline is an extremely dangerous substance commonly found in households; it is seldom disposed of, but when dumped presents acute and chronic toxicity problems as well as acute flammability concerns.

Ethylene glycol in antifreeze presents an acute toxicity problem in concentrated form (as in car radiators), but appears to be broken down adequately if diluted in sewage treatment systems or soil.

5. Summary

Each class of products tends to have its particular areas of concern; this could be labeling deficiencies, the toxicity or persistence of the contents, the disposal route, volumes used, etc. Three kinds of products are "red-flagged" as being of special interest in that they all have the potential to harm the environment, they are used in significant quantities, and they may be disposed of in harmful ways. These are:

- Pesticides;
- Solvents, especially the chlorinated organics; and
- Motor oil.

SECTION VI

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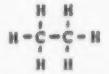
APPENDIX A

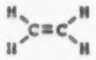
A QUICK-AND-DIRTY ORGANIC CHEMISTRY LESSON

Information in this section has been substantially taken from Mortimer (1971), with additions from Morrison and Boyd (1973).

Organic chemistry is commonly defined as the chemistry of carbon compounds. Some carbon compounds, such as carbon dioxide, carbonates and cyanides, are traditionally classified as inorganic compounds. Organic chemistry is probably better defined as the chemistry of hydrocarbons (compounds containing carbon and hydrogen) and their derivatives.

Carbon forms an unusually large number of compounds because of its ability to form compounds in which many carbon atoms are bonded to each other in chains or rings. In addition, the carbon atom can form either four very stable single covalent bonds, or fewer than four single bonds and one multiple bond (either double or triple):





$H-C\equiv C-H$

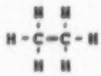
Organic compounds can be classified into two major groups: aliphatic and aromatic. Aliphatic hydrocarbons are open-chain structures not based on the benzene ring. Aromatic hydrocarbons are single or multiple ring structures based on the benzene (C_6H_6) ring. These two groups, their components and derivatives are discussed below.

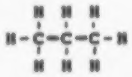
A. ALIPHATIC HYDROCARBONS

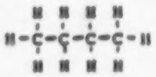
Aliphatic hydrocarbons are open-chain structures and include such compounds as the alkanes, alkenes and alkynes and their derivatives. The simplest aliphatic hydrocarbon is methane, CH_4. This molecule contains four equivalent carbon-hydrogen bonds, each bond of the same length and angle.

1. The Alkanes

Alkanes are hydrocarbons in which all the carbon-carbon bonds are single bonds; they may be considered to be of $-CH_2-$ units. Examples of alkanes include ethane, propane, pentane and octane, which contain 2, 3, 4, 5 and 8 carbons, respectively:

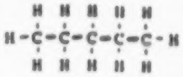

ethane

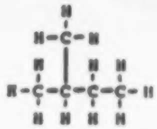

propane

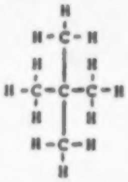

butane

These compounds are spoken of as straight-chain aliphatics even though the carbon chains are not exactly linear; all the bond angles are approximately tetrahedral and rotation of any carbon atom around a single bond of the chain is possible without changing the basic structure.

In addition to forming straight-chain compounds, alkanes can also form compounds with a branched chain or cyclic (ring) structure. The branched chain can result in compounds with the same molecular formula but different structural formulas and different properties; these are called structural isomers. For instance, for the formula C_5H_{12} there are three structural isomers: penthane (which is a straight-chain compound), methyl butane, and dimethyl propane.


pentane


methyl butane


dimethyl propane

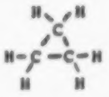
A branched-chain compound may be named in terms of the longest straight chain in the molecule. The side chains are named as alkyl radicals, and their position on the straight chain is usually indicated by a numbering system. Alkyl radicals are fragments of alkane molecules from which a hydrogen atom has been removed; their names are derived from the name of the parent alkane with the ending changed to -yl. Some common alkyl radicals are:

methyl
ethyl
normal-propyl (n-propyl)
isopropyl
normal-butyl (n-butyl)
isobutyl
secondary-butyl (sec-butyl)
tertiary-butyl (tert-butyl)

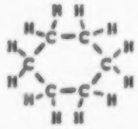
In the name, a number is used to indicate the position of each substitute radical; thus the name "2,2-dimethyl-3-ethylpentane" indicates that the radicals are located off the second and third carbons in the five carbon straight chain. The name "methyl propane," however, requires no number to indicate position because there is only one position available for the methyl group. Names for some of the higher straight-chain alkanes, and their physical properties, may be seen in Table 49.

With increasing molecular weight, the melting points and boiling points increase.

The cyclic alkanes are ring structures that contain only single carbon-carbon bonds. They are basically open-chain aliphatics that have formed into a ring, but which are not based on the C_6H_6 ring of benzene (see below). Examples are cyclopropane and cyclohexane:



cyclopropane



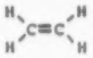
cyclohexane

Petroleum is the principle source of alkanes and cyclo-alkanes. In the refining of petroleum, the crude oil is first separated into fractions by distillation. (See Table A-2.) Some higher boiling fractions are subjected to cracking processes

> in which large molecules are broken down into smaller molecules, thus increasing the yield of the most valuable fraction, gasoline. In addition, small molecules are converted into larger ones in what are called alkylation processes. Gases that are by-products of these processes, together with the petroleum fractions and substances obtained from the fractions, comprise important starting materials for the manufacture of many chemical products. More than 2,000 such products (such as rubber, detergents, plastics, and textiles) are derived from the substances obtained from petroleum and natural gas (Mortimer, 1971).

2. The Alkenes

The alkenes (also known as olefins) are aliphatic hydrocarbons that have a carbon-carbon double bond somewhere in their structure. The first member of the series is ethene (also known by its old name, ethylene).



All six atoms lie in the same plane, and all bond angles are approximately 120°. Free rotation around the carbon-carbon bond is not possible. The carbon-carbon bond distance in ethene is shorter than in ethane because of the double bond.

Alkanes are called saturated compounds because all the valence electrons of the carbon atoms are engaged in single bond forma-

TABLE A-1. STRAIGHT-CHAIN ALKANES
(Mortimer, 1971)

Compound	Formula	Melting Point (°C)	Boiling Point (°C)
Methane	CH_4	-183	-162
Ethane	C_2H_6	-172	-88
Propane	C_3H_8	-187	-42
Butane	C_4H_{10}	-135	1
Pentane	C_5H_{12}	-131	36
Hexane	C_6H_{14}	-94	69
Octane	C_8H_{18}	-57	126
Nonane	C_9H_{20}	-54	151
Decane	$C_{10}H_{22}$	-30	174
Hexadecane	$C_{16}H_{34}$	20	288
Heptadecane	$C_{17}H_{36}$	23	303

Table A-2. PETROLEUM FRACTIONS. (Mortimer,1971.)

Fraction	Boiling Range (°C)	Carbon Content	Use
Gas (LPG)	below 20	C1-C4	fuel
Petroleum ether	20-90	C5-C7	solvent
Gasoline	35-220	C5-C12	motor fuel
VM&P Naphtha	94-175	unknown	solvent
Mineral spirits or Stoddard solvent	152-210	unknown	solvent
Kerosene	200-315	C12-C16	jet fuel
Fuel oil	250-375	C15-C18	diesel fuel
Lubricating oil	35 and up	C16-C20	lubrication
Parafin wax	50-60 (m.p.)	C20-C30	candles
Asphalt	viscous liquid		paving
Residue	solid		fuel

tion, and no more hydrogen atoms, or atoms of other elements, can be accommodated by the carbon atoms of the chain. Unsaturated compounds, such as the alkenes, can undergo addition reactions because of the availability of the electrons of the double bond. In one such reaction, hydrogen adds to ethene to form ethane (Mortimer, 1971).

The name of an alkene is derived from the name of the corresponding alkane by changing the ending from -ane to -ene; a number is used, where necessary, to indicate the position of the double bond. New types of isomers also arise in the alkene series, but these quickly become very confusing and we will not attempt to examine them here.

3. The Alkynes

Molecules that contain carbon-carbon triple bonds are known as alkynes. The first member of this series is ethyne (better known by its old name, acetylene).

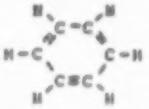
$$H-C\equiv C-H$$

The four atoms of the acetylene molecule lie in a straight line. The carbon-carbon triple bond distance is shorter than the carbon-carbon double or single bond distances. All alkynes readily undergo addition reactions across the triple bond because of the availability of electrons.

Alkynes are named in a manner analogous to that employed in naming alkenes; the ending -yne is used in place of -ene. Their physical properties are similar to those of the other aliphatic hydrocarbons (Mortimer, 1971).

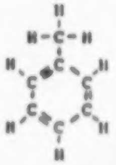
B. AROMATIC HYDROCARBONS

Aromatic hydrocarbons are compounds with structures based on the unique cyclic or ring form, benzene (C_6H_6).

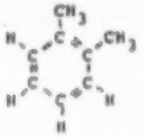


The entire structure is planar and all the bond angles are 120°. The six carbons are equidistant, the "double" and "single" bonds rotating or merged into a shared arrangement unlike the illustration above, with the electrons evenly distributed around the ring. This results in a very stable structure and is responsible for the properties that are typical of aromatic compounds. The benzene ring does not readily undergo addition reactions like alkenes and alkynes do.

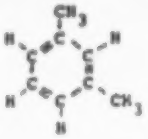
A methyl ($-CH_3-$) radical added to a benzene ring produces the compound toluene (which could, by naming procedures described above, be called methyl benzene):



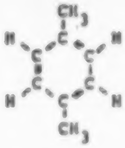
Adding two methyl radicals onto benzene produces xylene. There are, however, three position isomers of any disubstituted benzene derivative. The prefixes ortho- (o-), meta- (m-), and para- (p-) are used to designate the positions of the two substitute groups, as in o-xylene, m-xylene and p-xylene:



o-xylene



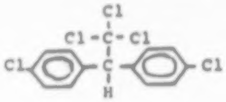
m-xylene



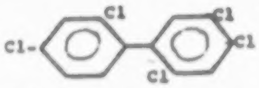
p-xylene

Numbers are used when more than two substitutes are present on the ring (e.g., 1,3,5-trinitrobenzene).

When the substitutes get complex, or when more than one ring is involved in the compound, the benzene ring portion of the structure is referred to as a phenyl group. Two infamous examples of such compounds are DDT and PCBs:



Dichloro-Diphenyl-Trichloroethane



Poly-Chlorinated Biphenyl

Coal is a major source of aromatic compounds for industrial production. In the preparation of coke for industrial use (principally the reduction of iron ore), bituminous coal is heated out of contact with air in retorts. Coal tar, a by-product of this process, is a black, viscous material from which various aromatic compounds may be separated. Aromatic compounds are also obtained from processes that utilize the alkanes and cycloalkanes derived from petroleum (Mortimer, 1971).

C. DERIVATIVES

1. Alcohols and Ethers

The alcohols may be considered as derivatives of hydrocarbons in which a hydroxyl group (-OH) replaces a hydrogen. The hydroxyl group is one of a number of functional groups, which are groups of atoms that give organic compounds bearing them characteristic chemical and physical properties (Mortimer, 1971).

The compounds are named as derivatives of a hydrocarbon consisting of the longest straight chain that contains the OH group. The ending of the parent hydrocarbon is changed from -ane to -anol, and numbers are used to indicate the positions of substituents, the lowest possible number being assigned to the OH group. Alcohols may be classified as primary, secondary, or tertiary, according to the number of alkyl radicals on the carbon atom holding the OH. Thus there is 1-butanol (primary alcohol), 3-methyl-2-butanol (secondary alcohol) and 2-methyl-2-butanol (tertiary alcohol).

Alcohols associate through hydrogen bonding. For this reason, the melting points and boiling points of the alcohols are higher than those of alkanes of corresponding molecular weight. The lower alcohols are miscible with water in all proportions because of intermolecular hydrogen bonding. However, as the size of the alkyl radical increases, the alcohols become more like alkanes in their physical properties, and the higher alcohols are only slightly soluble in water (Mortimer, 1971).

The first member of the series, methanol or methyl alcohol, is known as wood alcohol because it can be obtained by the destructive distillation of wood. The principal commercial source of this alcohol is the catalytic hydrogenation of carbon monoxide. The alcohol of alcoholic beverages is ethanol, or ethyl alcohol. It is prepared by the fermentation of starches or sugars. Ethanol is also commercially prepared from ethane. The indirect addition of water to olefins by means of sulfuric acid is a general method of preparing alcohols (Mortimer, 1971).

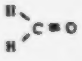
The reverse process, i.e., the elimination of one water molecule from one molecule of alcohol, produces an olefin or alkene. But if the process conditions are varied and one molecule of water is removed from two molecules of alcohol, an ether is produced. Ethers may be regarded as derivatives of water (H-O-H) in which both hydrogen atoms are replaced by alkyl groups (R-O-R). The alkyl groups may be alike or different:

$C_2H_5-O-C_2H_5$	$CH_3-O-C_2H_5$
ethyl ether	methyl ethyl ether

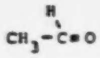
2. Carbonyl Compounds

A carbon atom can form a double bond with an oxygen atom to produce what is called a carbonyl group (-C=O). The carbonyl double bond differs from the olefinic double bond in that it is markedly polar since oxygen is more electronegative than carbon.

If the carbonyl group is bonded to one alkyl group and a hydrogen, or to two hydrogens, the compound is an aldehyde (e.g., formaldehyde, acetaldehyde):

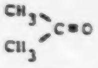


formaldehyde

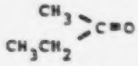


acetaldehyde

In a ketone, the carbonyl group is bonded to two alkyl groups which may be alike or different:



acetone

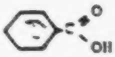


methyl ethyl ketone

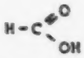
The double bond of the carbonyl group readily undergoes many addition reactions.

3. Carboxylic Acids and Esters

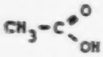
Oxidation of the aldehyde group yields a carboxyl group (-COOH). Compounds containing the carboxyl group are weak acids (carboxylic acids):



benzoic acid



formic or methanoic acid



acetic or ethanoic acid

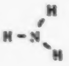
Carboxylic acids react with alcohols to produce compounds known as esters. The name of an ester reflects the alcohol and acid from which it is derived, the ending -ate being employed with the base of the name of the acid to give the second portion of the name of the ester (such as ethyl acetate).

The lower molecular weight esters have pleasant, fruity odors. Esters of high-molecular-weight carboxylic acids and glycerol are animal and vegetable fats: glyceryl esters that are liquids at room temperature are commonly called oils. The carboxylic acids are long-chain structures which may be saturated or unsaturated, i.e., have all single bonds or some multiple bonds, respectively. Liquid fats, or oils, contain a high percentage of glyceryl esters of unsaturated acids. Hydrogenation of vegetable oils produces solid fats. In commercial practice, the process is run only until a solid of the desired consistency is obtained; not all of the olefinic linkages are saturated.

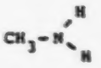
The alkaline hydrolysis of an ester produces an alcohol and a salt of a carboxylic acid. The salts of long-chain carboxylic acids are soaps (Mortimer, 1971).

4. Amines and Amides

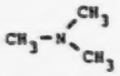
The amines may be considered as derivatives of ammonia with one, two, or three hydrogen atoms replaced by alkyl groups:



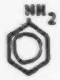
ammonia



methylamine



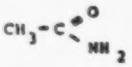
trimethylamine



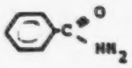
aniline

The amines resemble ammonia in that they are weak bases.

Amides are produced from ammonia and carboxylic acids:



acetamide



benzamide

Carboxylic acid molecules that contain an amino group ($-NH_2$) on the carbon atom adjacent to the carboxyl carbon are called amino acids. Many amino acid units are linked together to form proteins.

5. Polymers

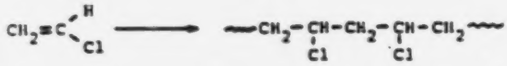
Starch, cellulose, and proteins are examples of natural polymers -- molecules of high molecular weight that are formed from simpler molecules, called monomers. Important polymers, or macromolecules, that do not occur in nature have been synthesized; most of these are linear, or chain-type, structures although some are cross-linked.

Many polymers are formed from compounds that contain carbon-carbon double bonds by a process that is called addition polymerization. For example, ethene (ethylene) polymerizes upon heating (100°C - 400°C) under high pressure (1,000 atm); the product is called polyethylene:

$$\underset{\text{ethylene}}{CH_2=CH_2} \longrightarrow \underset{\text{polyethylene}}{\sim CH_2-CH_2-CH_2-CH_2-CH_2\sim}$$

The polymerization process continues, by successive additions of molecules, until chains of hundreds or thousands of units are produced.

Important polymers have been made from ethene derivatives. Orlon® and Acrilan® are polymers of acrylonitrile. Vinyl chloride and vinyl acetate are important monomers in the preparation of vinyl plastics. Lucite®, or plexiglass, is a polymer of methyl methacrylate.



vinyl chloride

polyvinyl chloride (PVC)

The product formed by the polymerization of two different monomers is called a copolymer. The molecular structure and properties of such materials depend upon the proportions of the two monomers employed.

Condensation polymerization occurs between molecules of monomers by the elimination of a small molecule, usually water. Proteins and polysaccarides are condensation polymers. Dacron® is a polyester formed by the elimination of water between ethylene glycol and a dicarboxylic acid.

APPENDIX B

HAZARDOUS WASTES AND TOXIC SUBSTANCES

A. HAZARDOUS WASTE

1. What is Hazardous Waste?

RCRA (Resource Conservation and Recovery Act) -- see below -- defines hazardous waste as "solid waste that may cause or significantly contribute to serious illness or death, or that poses a substantial threat to human health or the environment when improperly managed" (Oregon Department of Environmental Quality, 1981). It may come from many sources in our technological society, including hospitals, laboratories, and all levels of government, although industry is by far the largest source. Out of this, the chemicals and allied products industry generates 60 percent of industrial waste (U.S. EPA, 1980a). Hazardous waste generation also tends to be concentrated geographically: 60 percent is generated in 10 states (New Jersey, Illinois, Ohio, California, Pennsylvania, Texas, New York, Michigan, Tennessee and Indiana) (U.S. EPA, 1980a).

A substance is considered a hazardous waste if it falls under one of two situations:

- If it is found on the list of hazardous wastes that EPA has compiled, or
- If it is tested and found to possess any one of the following four characteristics (taken extensively from U.S. EPA, 1980a):
  - Ignitability -- poses a fire hazard during routine management;
  - Corrosivity -- requires special containers because of ability to corrode standard materials, or requires segregation from other wastes because of ability to dissolve toxic contaminants;
  - Reactivity (explosiveness) -- tends to react vigorously with air or water, to explode or generate toxic gasses, and in general to be unstable during routine management;
  - Toxicity -- releases toxicants in sufficient quantities to pose a substantial hazard to human health or the environment.

Some wastes have more than one of these characteristics -- for instance, gasoline is both ignitable and toxic.

Thus, all discarded toxic substances are hazardous wastes, but not all hazardous wastes are toxic substances.

2. How are Hazardous Wastes Controlled?

In 1976, Congress enacted Subtitle C of Resource Conservation and Recovery Act (RCRA) to impose strict controls over the management of hazardous wastes. A complete examination of RCRA and other hazardous waste regulations can be found in Part "A" of this report series. Briefly, however, RCRA established a national program with three phases to protect human health and the environment.

The first phase consists of a regulatory program, whose central focus is a "cradle to grave" control system to track all significant quantities of hazardous wastes. This regulatory program also establishes how hazardous wastes are identified, the standards which generators and transporters must follow, operating requirements for treatment facilities, a permit system, and guidelines for state programs.

The second phase of RCRA consists of investigations to identify dangerous abandoned dump sites and to force the owners to clean them up. If the owners cannot be found, then the third phase is put into effect. This is actually a separate piece of legislation, the Comprehensive Environmental Response, Compensation, and Liability Act, also known as "Superfund." It provides money to clean up abandoned dump sites, as well as spills of oil and hazardous substances.

Hazardous waste need not be a disposal problem. There are other management options for controlling hazardous wastes; some alternatives are:

- reduction of the amount of waste generated by changing the manufacturing process (using substitutes, keeping wastes separate, etc.);
- reuse of the waste by transferring it to another industry;
- recycling of the waste by removing contaminants and reusing it;
- incineration or treatment of the waste by physical or biological processes;
- disposal at a secure landfill.

3. What is Household Hazardous Waste?

In relation to what we now know about hazardous waste, what is household hazardous waste? According to RCRA, the term "hazardous waste" does not apply to normal quantities of any substance, even if it is dangerous or highly toxic. The difference between what is normally called "hazardous waste" and what we are calling "household hazardous waste" relates not so much to the level of toxicity or degree of hazard, but to the quantities of waste involved. Household hazardous wastes are smaller amounts of hazardous wastes. For instance, in Washington State, only hazardous wastes in excess of 400 pounds per month (or batch) are regulated -- household wastes fall well below that exclusion limit. Furthermore, the law specifically exempts household wastes regardless of hazardous potential.

In addition to their definition by quantity, household hazardous wastes can sometimes be differentiated from industrial/commercial hazardous waste by content. Although households will often use the same chemical that is used in an industrial or commercial process, manufacturers will sometimes produce special formulations for use in the home. This may be done for a number of reasons, including safety, legal restrictions, dispensibility or in response to unique conditions in the home. Pesticide formulations for household use are often different than those for commercial use, for instance, or cleaning solutions may be diluted or may use less toxic ingredients.

As mentioned above, a toxic waste is one kind of hazardous waste. Many of the products found in households are of concern primarily because of their toxicity (though they might also be corrosive, flammable, etc.). The following analysis of toxicity and toxic substances is intended to help in understanding the nature of household hazardous waste.

B. TOXIC SUBSTANCES

1. What is a Toxic Substance?

A chemical and a substance are the same thing. Toxic means poisonous. In the broadest sense, then, a toxic substance is a chemical which is able to produce an adverse biological effect or in some way damage -- poison -- a living organism. This definition is not very helpful, however, because every chemical can be toxic if too much of it is present, i.e., if the concentration is too high for the particular circumstances. Water is toxic to a person submerged in it. Obviously many foods, such as oranges, are virtually non-toxic. Other substances are so poisonous that a single taste can be deadly -- Botulinus toxin is one example. In this light we can say that there are no harmless substances, only harmless ways of using substances. The reverse of this is also true: There are no toxic substances, only harmful ways of using substances. If the Botulinus toxin never gets out of the can, for instance, it is harmless. Through TSCA (Toxic substances Control Act), Congress has loosely defined a toxic substance as a chemical or mixture of chemicals whose manufacture, processing, distribution, use or disposal of may present an unreasonable risk of injury to health or the environment (Segel et al., 1980). Risk is measured in two ways: 1) by the inherent toxicity of the chemical (e.g., oranges versus Botulinus), and 2) by the amount of exposure. The first factor is measured by toxicological testing, (usually on animals) -- more on that later. The amount of exposure is determined by finding out how much is entering the environment, what happens once it gets there, and the hazards that it poses throughout its life (including products of degradation).

Thse two factors are taken together to determine the severity of the risk. Decision-makers estimate the potential benefit to society, balance the risk against the benefit, and thereby determine whether there exists an "unreasonable risk" of injury. This entire process is obviously very complicated, and the final assessment must always come down to a value judgement.

2. Toxic Exposure and Dose

Acute means sudden or immediate. Chronic means long-term. These two words are used in two ways when talking about toxicity. We can speak of acute or chronic exposure and acute or chronic effects. Acute exposure is a single or very brief exposure; a one-time event. Chronic exposure is repeated exposure over a long period of time, and in light of that, it is important that the doses and exposures of the chemical substance in question be well-understood. Six abbreviations are used to describe the administered doses. These terms indicate whether the dose caused death (Lethal Dose - LD) or other toxic effect (TD) and whether it was administered as a lethal concentration (LC) or toxic concentration (TC) in the air or water. In general, the term "Lo" refers to the lowest dosage which shows any effect on an organism. Table B-1 describes the different types of experimental exposure.

How an organism is exposed to a toxic substance determines whether there will be an effect or not. A toxic substance can be absorbed by living organisms through skin contact, eating and drinking (oral ingestion) or breathing (inhalation). It can cause problems directly by damaging the surface of the body (a local effect) or it can pass through the skin or be absorbed in the body and cause systemic effects of an acute or chronic nature.

Although many exposures to substances in the home or at work occur via inhalation or skin absorption, most studies report exposures in which the substances were introduced through the mouth. Table B-2 shows some of the other common routes of exposure, some of them applicable in experimental situations only.

Table B-1. DEFINITION OF EXPOSURE TERMS.
(Lewis and Tatken, 1979.)

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1. TDLo: Toxic Dose Low -- the lowest dose of a substance introduced by any route (other than inhalation) over any given period of time and reported to produce any toxic effect in humans or to produce carcinogenic, neoplastic, teratogenic, or mutagenic effects in humans or animals.

2. TCLo: Toxic Concentration Low -- the lowest concentration of a substance in air or water to which humans or animals have been exposed for any given period of time that has produced any toxic effect in humans or produced a carcinogenic, neoplastigenec, teratogenic, or mutagenic toxic effect in animals or humans.

3. LDLo: Lethal Dose Low -- the lowest dose of a substance introduced by any route (other than inhalation) over any given period of time in one or more divided portions and reported to have caused death in humans or animals.

4. LD50: Lethal Dose Fifty -- a calculated dose of a substance which is expected to cause the death of 50 percent of an entire defined experimental animal population. It is determined from the exposure to the substance by any route other than inhalation of a significant number from that population. Other lethal dose percentages, such as LD1, LD10, LD30, and LD99, may be published in the scientific literature for the specific purposes of the author.

5. LCLo: Lethal Concentration Low -- the lowest concentration of a substance in air or water which has been reported to have caused death in humans or animals. The reported concentrations may be entered for periods of exposure which are less than 24 hours (acute) or greater than 24 hours (subacute and chronic).

6. LC50: Lethal Concentration Fifty -- a calculated concentration of a substance in air or water, exposure to which for a specified length of time is expected to cause the death of 50 percent of an entire defined experimental animal population. It is determined from the exposure to the substance of a significant number from that population.

Table B-2. ROUTES OF ADMINISTRATION TO, OR EXPOSURE OF ANIMAL SPECIES TO TOXIC SUBSTANCES IN LAB TESTS. (Lewis and Tatken, 1979.)

Route	Abbreviation	Definition
Eyes	eye	Administration directly onto the surface of the eye. Used exclusively for primary irritation data. See Ocular.
Intradermal	idr	Administration within the skin by hypodermic needle.
Inhalation	ihl	Inhalation in chamber, by cannulation, or through mask.
Intramuscular	ims	Administration into the muscle by hypodermic needle.
Intraplacental	ipc	Administration into the placenta.
Intraperitoneal	ipr	Administration into the peritoneal cavity.
Intravenous	ivn	Administration directly into the vein by hypodermic needle.
Ocular	ocu	Administration directly onto the surface of the eye or into the conjuctival sac. Used exclusively for systematic data.
Oral	orl	Through the mouth, intragastric, feeding, or introduction with drinking water

(continued)

Table B-2. ROUTES OF ADMINISTRATION TO, OR EXPOSURE OR ANIMAL SPECIES TO TOXIC SUBSTANCES IN LAB TESTS. (Continued)

Route	Abbreviation	Definition
Percutaneous	per	Absorbed through the skin.
Skin	skn	Application directly onto the skin, either intact or abraded-used both for systemic and primary irritant effects. (see below)
Subcutaneous	scu	Administration under the skin.

Toxic substances are tested on animals since potentially dangerous experiments cannot be done on people. Mice and rats are most commonly used for such tests because they are easily handled and economical, and react similar to humans in their response to chemicals. They therefore provide the most useful data for comparisons. Rabbits, guinea pigs, and monkeys are other commonly used test species.

Test animals are exposed to much higher doses than the low levels at which humans are most often exposed. This is because lengthy tests with many subjects are expensive, and the chronic effects which are caused by long-term, low level exposure may also be produced by the short-term, high level dosage. Also, test animals such as rats have a two to three year natural lifetime and can thus show chronic (to rats) effects such as cancer in a relatively short period. For more information on this point, see National Cancer Institute, 1979a.

The units used to express toxic doses require a quick explanation. As in almost all toxicological experiments, the doses are expressed in terms of the amount of chemical administered per unit body weight, or quantity per unit volume of air. Depending on the experiment, the duration of time (e.g., 96 hours) over which the dose was given is also expressed. The most common unit of measurement is milligrams per kilogram (mg/kg), but sometimes grams per kilogram (g/kg) or micrograms per kilogram (ug/kg) may be used. When the substance is a gas, the concentrations are given as parts of substance per million parts of air by volume (ppm), and sometimes as parts per hundred (pph) or parts per billion (ppb). If the substance is a solid or a liquid suspended in air, then the concentrations are usually expressed as milligrams per cubic meter of air (mg/m^3), or, in some cases, as micrograms per cubic meter (ug/m^3).

3. Toxic Effects

Acute and chronic effects depend on how toxic the substance is, and what the dose is. And, in the case of chronic toxicity, the frequency of exposure is also important.

Acute effects are the ill effects that occur immediately after exposure to too much of a toxic substance. For example, getting jittery after you drink coffee or soda pop with caffeine is an acute attack. Acute effects are often reversible, in that they may heal or go away with time.

Chronic effects are the ill effects that do not appear immediately but do appear after a period of time. Chronic effects often occur at doses too small to produce acute effects. A single acute exposure to some substances in early pregnancy may produce a baby with a birth defect, which is a chronic effect. On the other hand, repeated cigarette smoking (chronic exposure) might not lead to the development of lung cancer (a chronic effect) until many years after the person started smoking. Chronic effects are often irreversible -- once you have a birth defect, it will not heal.

One kind of toxic effect that can occur is an irritation. Toxic substances that are applied to the skin or mucuous membranes can result in systemic or local effects, the latter being termed "primary irritation." A primary skin or eye irritant is defined as "a chemical substance that produces an irritant response on first exposure in a majority of the test subjects" (Lewis and Tatken, 1979). There are many kinds of chronic effects. Some of the most common are:

- Liver or kidney damage: Organs that are primarily concerned with breaking down and getting ride of toxic substances in the body are damaged.
- Central nervous system (CNS) damage: Damage to the CNS (nerve cells in the brain and spinal cord) can be exhibited in minor ways, such as depression or slight changes in I.Q., or can consist of serious damage, such as paralysis.
- Cancer: The appearance and proliferation of abnormal and destructive tumor-producing cells can result from exposure to a cancer-causing agent, called a carcinogen. Some substances are indirect carinogens, i.e., they may damage certain body cells which then become more sensitive to other "cancer promoters" (Sasnett, 1979). Some carcinogens have

synergistic effects on each other in that the risk of cancer may be increased if exposed to two carcinogens at the same time.

- Neoplasm: The appearance and proliferation of tumor or growth cells which may not be abnormal and which do not invade and destroy other tissues may result from some chemical exposures. These tumors or growths may be benign or malignant (Lewis and Tatken, 1979).

- Mutation: A change in the genetic material of sperm or egg cells can lead to an undesirable inherited condition and can be caused by exposure to mutagen. A mutation is inheritable from cell to cell but not necessarily from individual to individual (Segal et al., 1980). The effect may be a subtle change, such as decreased resistance to disease, or a gross malformation such as a birth defect.

- Teratogenic effect: A birth defect produced by a disturbance of natural development of a fetus during pregnancy can be caused by exposure to a teratogen. The effect can also be subtle (e.g., a learning disability) or a gross deformation. Only pregnant women are subject to the effects of teratogens.

C. TOXIC VERSUS HAZARDOUS

What precisely is the difference between "toxic" and "hazardous?" Dictionary definitions present toxic as "poisonous" and hazardous as "dangerous." The terms, however, are often used interchangeably -- including in this project and its reports -- and much confusion exists over their specific meanings. The Chemical Specialties Manufacturers Association recommends a clear distinction:

> The term "toxicity" means the net effect of a substance or other agent on an organism, while "hazard" represents a significant risk of harm in a particular situation. All substances or agents have some degree of toxicity, but a hazard exists only if the exposure presents a significant risk of adverse effect. Toxicity is not equivalent to hazard, and [one] should refrain from characterizing products or chemicals as hazardous without assessing the potential risk (CSMA, 1982).

In legal and general usage, however, such distinction is not made. Definitions from various federal laws are as follows:

- Hazardous waste (RCRA): A solid waste substance that may "cause or significantly contribute to..." serious illness or death or "pose a substantial present or potential hazard to human health or the environment" when improperly managed;

- Toxic substance (TSCA): A chemical whose manufacture, processing, distribution, use or disposal "may present an unreasonable risk of injury to health or the environment;"

- Hazardous substance (Clean Water Act): An element and compound which, "when discharged in any quantity into or upon [water]..., present[s] an imminent and substantial danger to the public health and welfare...;"

- Toxic pollutant (Clean Water Act): A substance which, "after discharge and upon exposure, ingestion, inhalation or assimilation into any organism..., will, on the basis of information available..., cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring;"

- Hazardous substance (Federal Hazardous Substances Act): Any substance which "may cause substantial personal injury or substantial illness during...any customary or reasonably foreseeable handling or use;"

- Hazardous air pollutant (Clean Air Act): A substance which "causes, or contributes to, air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious...illness;"

- Hazardous material (Hazardous Materials Transportation Act): A substance or material which is "capable of posing an unreasonable risk to health, safety, and property when transported in commerce..."

Almost all of these definitions, whether of toxic or hazardous, refer to an assessment of risk and use such qualifiers as significant, unreasonable, substantial, or reasonably anticipated.

In general, hazardous is a more inclusive term and refers to materials that pose a threat or risk of injury -- are dangerous -- because they are explosive, corrosive, flammable, reactive, or toxic. Toxic, in its common usage, refers to materials that pose the specific threat or risk of injury of poisoning (in its broadest sense) producing an adverse biological effect in the exposed organism or its offspring. Toxic in this usage is a subset of hazardous, and does connote hazard or risk.

In this Household Hazardous Waste Disposal Project and throughout these reports, toxic is used in this manner (i.e., a specific class of hazardous) and hazardous is generally used to refer only to its toxic class. Where the word "hazardous" is seen (as in Household Hazardous Waste), read "toxic hazardous."

APPENDIX C-1

GLOSSARY

acute toxicity: The ability to cause short-term health effects by a single or short-term exposure. It is quantitatively expressed as LD50 or LC50. See also Appendix B.

aliphatic: Of or pertaining to any organic compound of hydrogen and carbon characterized by a straight chain of carbon atoms. See Appendix A.

Ames test: A short-term, in vitro mutagenic bioassay using bacterial culture. It is rapid, economical and sensitive and enables the tester to screen large numbers of chemicals.

anemia: A condition in which there is a reduction in the number or volume of red blood cells or the amount of hemoglobin.

anorexia: Loss of appetite.

aromatic: Pertaining to or characterized by the presence of at least one benzene ring. See Appendix A.

aromatic solvent naphtha: A mixture of inconstant composition prepared from the distillation of coal (sometimes from petroleum in current practice). Contains xylene, ethyl benzene, cumene, and perhaps toluene. Traces of benzene and pyridine derivatives may be present.

aspirate: To draw in or out by suction; to suck in.

auxin: Plant-sprout hormone promoting growth in plant cells and tissues.

bioassay: The determination of the toxicity of a chemical by comparing its effect on a live animal, microorganism, or isolated organ to the effect on a control or of known chemical.

biodegradable: The capacity to be chemically degraded by natural action such as light, moisture or bacteria over a relatively short period of time.

bradycardia: A slow heart beat characterized by a pulse rate that is under 60 beats per minute.

builders: Those ingredients in modern detergents that are designed to chelate or otherwise remove the elements responsible for water hardness (mostly calcium and magnesium) and to prevent the inactivation of ingredients that serve as surfactants. Also called "sequestrants". See page 104.

carcinogen: A cancer-causing substance. See Appendix B.

cation: An ion with a positive charge of electricity.

chloracne: A severe type of contact dermititis in humans, produced by high levels of chlorophenoxy herbicides.

cholinesterase: Any enzyme which catalyzes the hydrolysis of choline esters. Choline is an amine, widely distributed in plant and animal tissues, which is essential in normal fat and carbohydrate metabolism, and is involved in protein metabolism.

chronic toxicity: The adverse health effects resulting from long-term or repeated exposure to toxic substances. It can be expressed in many forms including carcinogenicity, mutagenicity, and teratogenicity. The effect may be irreversible or reversible. See Appendix B.

coal tar distillate: An aromatic hydrocarbon solvent, including: benzene, toluene, xylene, cumene, ethyl benzene, mesitylene, and related compounds. For many years, the principal commercial source of aromatic hydrocarbons has been the destructive distillation of coal, but petroleum is now an important source.

conjunctivitis: Inflammation of the mucous membrane which lines the eyelids and is reflected onto the eyeball.

cornea: The clear, transparent anterior portion of the fibrous coat of the eye.

dermatitis: Inflammation of skin evidenced by itching, redness and various skin lesions.

desiccation: The process of drying up.

detoxification: Chemically changing a substance into one that is less toxic.

dyspnea: Air hunger resulting in labored or difficult breathing. Normal when due to vigorous activity.

effluent: The liquid waste of sewage and industrial processing.

essential oils: (e.g., Savin, Rue, Tansy, Juniper, Cedarleaf) Contains several aromatic hydrocarbons, phenols and nitrobenzene. More toxic than turpentine. In most cases a teaspoonful may cause illness in an adult and less than an ounce may kill (especially if vomiting does not occur promptly). Savin produces more renal damage than turpentine, and pennyroyal more liver degeneration.

eutrophication: The process whereby a freshwater system (lake, pond, etc.) becomes rich in plant nutrient minerals and organisms, which then causes an oxygen deficiency.

fibrosis: Abnormal formation of fibrous tissue, either in capillaries and heart, or in lungs. Fibrosis of lungs consists of formation of scar tissue in connective tissue framework of lungs following inflammation or pneumonia.

gastritis: Inflammation of the stomach.

gastroduodenitis: Inflammation of the stomach and duodenum.

glottal edema: A localized condition in the glottis, the sound-producing apparatus of the larynx, in which the tissues contain an excessive amount of tissue fluid.

halogenated hydrocarbons: An organic chemical with one or more of the halogen atoms attached. The halogens are a class of highly reactive chemicals, and include fluorine, chlorine, bromine, iodine, etc. See Appendix A.

hazard: Representing a significant risk of harm in a particular situation. See Appendix B.

hazardous material: Any poisonous, corrosive, flammable, explosive or radioactive material which could endanger human health or well-being if handled improperly. See Appendix B.

heavy metal: A metal whose specific gravity is approximately 5.0 or higher. Refers to a general class of elements including lead, zinc, cadmium, chromium, copper, nickel, arsenic, etc.

hepatic: Pertaining to the liver.

hexavalent: Having a chemical valence (ionic charge) of plus or minus six.

incineration: Disposal of solid, liquid or gaseous wastes by high temperature burning in a specially constructed device.

influent: An input stream of a fluid, such as water, into a reservoir or into a process vessel.

inorganic chemical: A chemical which does not contain carbon. Some carbonates which do contain carbon are still considered to be inorganic chemicals (such as CO_2).

intraperitoneal: Administration into the peritoneal cavity.

intravenous: Administration into a vein.

in vitro: In glass, as in a test tube. An in vitro test is one done in the laboratory, usually involving isolated tissue, organ or cell preparations.

in vivo: In the living body or organism. A test performed on a living organism.

irritant: A chemical which causes an inflammatory response in animals or humans. The response can occur at sites such as the skin, eyes, intestine, lungs or mucous membranes. See Appendix B.

kerosene (synonyms - range oil, home heating oil no. 1): A solvent and fuel prepared by the fractional distillation of petroleum (boiling point range is 347 to 617° F (175 to 325°C)). Consists chiefly of C_{10} to C_{16} hydrocarbons of the methane series, together with a small fraction of aromatic compounds (xylenes, etc.) and of saturated rings (naphthenes). Individual compositions vary widely, depending on the source.

leachate: The liquid that has percolated through soil or other medium, taking with it materials originally deposited elsewhere.

mutagen: A substance which alters the genetic structure of a cell, especially reproductive cells. See Appendix B.

myocardium: The middle layer of the walls of the heart, composed of cardiac muscles.

narcotic: A chemical which depresses the central nervous system, relieving pain and producing sleep. In excessive doses produces unconsciousness, stupor, coma and possibly death.

neoplasms: A new and abnormal formation of tissue as a tumor or growth. It may be benign or cancerous. See Appendix B.

nephritis: Inflammation of the kidney.

non-Ferrous metals: Metals other than iron.

organic chemical (synonym-hydrocarbon): A chemical containing carbon, except for certain carbonates such as calcium carbonate, carbon dioxide or carbon monoxide.

oxidative phosphorylation: The final stage of cellular respiration, requiring oxygen, by which ATP is generated. ATP is a high energy compound that provides chemical energy for metabolic processes.

oxidizer: A substance, such as chlorate, permanganate, inorganic peroxide, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter.

particulates: Fine liquid or solid particles, such as dust, smoke, mist, fumes or smog, found in emissions or air.

percutaneous: Administered through the skin.

peripheral neuropathy: Disease of the nervous system of the extremities.

pest: Any insect, rodent, nematode, fungus, weed, or other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other micro-organism (except those living in or on man or other living animals) which is deemed harmful.

pesticide: Any substance, or mixture of substances, intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture or substances intended for use as a plant regulator, defoliant or desiccant. These include insecticides, herbicides, rodenticides, fungicides, disinfectants, sanitizers, and wood preservatives.

petroleum distillate: A general term denoting any one of many fractions varying from petroleum ether to lubricating oils. Major fractions of crude petroleum in order of volatility are: petroleum ether (benzine), gasoline, kerosene, fuel oil, lubricating oils, paraffin wax, and asphalt or tar (pitch, coke). All fractions (when impure) tend to produce local skin irritation and, rarely, skin photosensitization.

petroleum ether (synonyms - petroleum benzin, petroleum benzine, light ligroin): A petroleum distillate consisting principally of n-pentane and n-hexane, with a boiling point range of 35° to 80° C (95° to 176° F). Petroleum ether may also refer to narrower "cuts" within the range specified above. May cause nervous depression. Not to be confused with benzene. See Appendix A and page 85.

petroleum naphtha: A general term describing petroleum distillates that consist of various mixtures of predominantly aliphatic (straight-chain or paraffinic) hydrocarbons (C_5 to C_{13}) boiling over the range 86 to 460°F (30 to 238°C). In the lower boiling range are petroleum ether and rubber solvent, in the mid-range the VM&P naphthas, and in the higher range Stoddard solvent. Thus petroleum naptha may refer to any cut more volatile than kerosene, but the work "naptha" alone is sometimes used as a synonym for petroleum ether. See Appendix A.

photolysis: Dissolution or disintegration under the stimulus of light rays (breaking down by sunlight).

phthalates: A family of aromatic hydrocarbon compounds also known as phthalate acid ester. They are durable oils widely used to extend or modify properties of plastics, and are also used in cosmetics, pesticides, industrial oils, etc.

phylactic: Concerning or producing an active defense of the body against infection.

plasmolysis: The shrinking of cytoplasm in a living cell due to loss of water by osmosis.

polycyclic aromatic hydrocarbons: A series of benzene rings; see aromatic hydrocarbons in Appendix A.

polymer: A compound formed from a number of smaller chemical units (monomers). Polymers are often, but not always, of high molecular weight. See Appendix A.

pre-RPAR review: The initial risk investigation of a pesticide which involves an extensive review of scientific studies; see "RPAR" under List of Abbreviations.

priority pollutant: As defined by the Clean Water Act of 1977, one of 65 toxic chemical groups of special interest because of their volumes of production or use, chemical stability, and potential for water contamination. The 65 were later expanded to include 126 inorganic and organic chemicals.

pulmonary edema: A localized condition in the lungs, in which the tissues contain an excessive amount of tissue fluid.

sensitizing agent: A substance which makes the susceptible individual react to the same or other irritants.

septage: The sludge produced in individual on-site wastewater disposal systems, such as septic tanks and cesspools.

sequestering agent: A substance that removes a metal ion from a solution system by forming a complex ion that does not have the chemical reactions of the ion that is removed. It can be a chelating or complexing agent. See "builder."

sewage: The fluid discharge from medical, domestic, and industrial sanitary appliances.

sewer: An underground pipe or open channel in a sewerage system for carrying water or sewage to a disposal area.

sewerage: The system of collection and treatment facilities (pipes, plants) for handling sewage.

solvent: The part of a solution that is present in the largest amount, or the compound that is normally liquid in the pure state.

Stoddard solvent (synonyms - mineral spirits no. 10, safety solvent naptha, white spirits): One of the higher-boiling fractions of petroleum naptha. Consists of a mixture of straight and branched chain paraffinic hydrocarbons (C9 to C12), napthenes (cycloparaffins), and higher aromatics, boiling in the range of 305-410 degrees F (152-210 degrees C). See also page 85 and Appendix A.

subcutaneous: Administered beneath the skin.

surfactant (synonym - surface active agent): A soluble compound that reduces the surface tension of liquids or reduces interfacial tension between two liquids, or a liquid and a solid. According to their use, surfactants may be classified as detergents, emulsifiers, wetters, or penetrants. Three general chemical classes are recognized on the basis of the ionization of the surface active moiety at neutral pH: anionic, cationic, and nonionic. See page 103.

synergism: The joint action of two or more agents which, when taken together, have a greater action than either one, alone.

systemic effects: Effects relating to the whole organism, as distinguished from any of its individual parts. See Appendix B.

teratogen: A substance causing birth-defects. See Appendix B.

toxic: Poisonous; a substance that causes adverse health and/or environmental effects. See Appendix B.

Toxicity: The net adverse effect of a substance or other agent on an organism. See Appendix B.

VM&P naptha (synonyms - varnish makers' and painters' naptha, petroleum spirits, ligroin, refined solvent naptha): Any of several petroleum "cuts" distilling between about 200 and 350 degrees F (04 to 175 degrees C), consisting chiefly of C_7 to C_{10} aliphatic (paraffinic) hydrocarbons. The terminology for these fractions is inconstant and misleading. For example, in commerce there are available at least three VM&P napthas with different flash points and somewhat different boiling point ranges within the limits specified above. See page 86 and Appendix A.

warning properties: An evaluation of the possibility that a substance will be detected at levels below the threshold limit value (TLV), either because of its odor threshold level, or its irritation level.

APPENDIX C-2

LIST OF ABBREVIATIONS

ACGIH: American Conference of Governmental Industrial Hygienists - Primary responsibility is the annual publishing of a list of "Threshold Limit Values of Airborne Contaminants and Physical Agents."

AWC: Ambient Water Criteria - The level of a chemical which will prevent harm to aquatic life. The Clean Water Act required EPA to establish criteria based on their knowledge of the effects on aquatic life. The values are based on technical data only; they carry no regulatory weight, and are intended to be used to establish state water quality standards. Value depends on fresh or salt water, acute or chronic effects.

CAG: Carcinogen Assessment Group of U.S. EPA.

CNS: Central Nervous System.

CPSC: Consumer Products Safety Commission - The primary responsibility is to protect the public against unreasonable risks of injury associated with consumer products.

DO: Dissolved Oxygen - The oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter or percent of saturation.

DOE: Department of Ecology - Washington State's counterpart to the Environmental Protection Agency.

DOT: U.S. Department of Transportation.

DMBA: 7, 12-dimethyl benz (a) anthracene - One of the most powerful synthetic polycyclic aromatic hydrocarbon carcinogens known.

EPA: U.S. Environmental Protection Agency - The main purpose of the agency is to control and abate pollution in the areas of air, water, solid waste, noise, radiation, and toxic substances This is done in cooperation with state and local governments.

FIFRA: Federal Insecticide, Fungicide and Rodenticide Act - This Act regulates the manufacture, use, and disposal of "economic poisons" for agricultural, forestry, household, and other activities.

GI: Gastrointestinal - Pertaining to the stomach and intestine.

HHWD: Household Hazardous Waste Disposal - Refers to the EPA-funded project which has produced this report, and instituted a control plan for small quantities of household toxicants in the Seattle area.

IARC: The United Nations International Agency for Research on Cancer.

IDLH: Immediately Dangerous to Life or Health - The maximum concentration to which a person can escape from within 30 minutes without suffering any impairing symptoms or irreversible health effects.

LC50: Lethal Concentration Fifty - A calculated concentration of a substance in air or water. Exposure to the concentration for a specified time period (usually four hours) is expected to cause the death of 50 percent of a defined population. Ambient concentration is expressed in milligrams per liter.

LD50: Lethal Dose Fifty - A calculated dose of a substance in which exposure to this dose for a specified time period is expected to cause the death of 50 percent of a defined population. Exposure may occur via any route other than inhalation. Dose concentration is expressed in milligrams per kilogram of body weight.

LWV: League of Women Voters.

$\mathrm{mg/m^3}$: Milligrams of a substance per cubic meter of air.

mp: Million pounds.

mppcf: Million particles per cubic foot.

NAS: National Academy of Science.

NCI: National Cancer Institute.

NIOSH: National Institute for Occupational Safety and Health - The Institute is involved with conducting research on which new standards can be based and for implementing education and training programs.

NRC: National Research Council.

OSHA: U.S. Occupational Safety and Health Administration - The government agency responsible for the development and enforcement of job safety and health standards.

PEL: Permissable Exposure Limit - The allowable level of contaminant in air, usually the federal standard as described in the Occupational Safety and Health Act (OSHA). PEL's are expressed in milligrams of contaminant per cubic meter of air (mg/m^3), and are for TWA (time-weighted average) levels -- that is for an eight-hour day, 40-hour per week work shift.

pH: A term used to describe the hydrogen ion activity of a system. A solution of pH 0 to 7 is an acid; pH of 7 is neutral; pH over 7, to 14 is alkaline.

ppb: Parts per billion - Used in reference to the amount of one substance in another, as the amount of a pollutant in water. Ppb is equivalent to micrograms per liter (ug/l), or micrograms per kilogram (ug/kg).

ppm: Parts per million - Used in reference to the amount of one substance in another as the amount of a pollutant in water. Ppm is equivalent to milligrams per liter (ug/l), or milligrams per kilogram (mg/kg). Also expressed as milligram percent (mg%) by physicians.

QAC: Quaternary Ammonium Compounds - Cationic Surfactants, see page 104.

RCRA: Resource Conservation and Recovery Act - Establishes a "cradle to grave" regulatory program for management of hazardous wastes, covering the identification standards for generation, transport, storage, and disposal of such wastes.

RPAR: Rebuttable Presumption Against Registration - A review process for pesticides, whereby EPA will "issue an "RPAR" whenever certain risk criteria are exceeded in any studies of the pesticide. This triggers an in-depth scientific review of the substance; if the presumption of risk can be rebutted, or the benefits shown to outweigh the risk, registration of the pesticide may be granted or continued. See Pre-RPAR in Glossary.

STEL: Short-term exposure limit - The maximum concentration to which workers can be exposed for periods up to 15 minutes continuously, without suffering from irritation, chronic or irreversable tissue change, or narcosis.

TCDD: Tetrachlorodibenzodioxin 2,3,6,7 - An extremely toxic contaminant of 2,4,5-T and possibly other pesticides.

TDLo: Toxic Concentration Low - The lowest concentration of a substance in air to which humans or animals have been exposed for any given period of time that has produced any toxic effects in humans or carcinogenic, neoplastigenic, teratogenic, or mutagenic toxic effect in animals or humans.

TL_m: Median Threshold Limit - The concentration of toxicant or substance at which 50 percent of the test organisms survive. Usually followed by a number (e.g., 96) which designates the length of time (e.g., 96 hours) the test was conducted. Because of the lack of test standardization and the variety of species investigated, ranges of toxicities rather than a single toxic dose are used.

TLV: Threshold limit value - The conditions under which it is believed that nearly all workers may be repeatedly exposed day-after-day without adverse effect.

TWA: Time weighted average - The average concentration of toxic substances to which the normal person can be exposed without injury for eight hours per day, five days per week, for an unlimited period. Excursions above the unit are permitted, provided they are compensated for by equivalent excursions below the limit during the work day.

ug/l: Micrograms per liter - equal to ppb.

uv: Ultraviolet - Beyond the visible spectrum of light at its violet end.

APPENDIX D:

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QAC	Glossary
Resmethrin (Pyrethrin)	37
Ronnel (Korlan®)	34
Rotenone	37
Round-up® (Glyphosate)	44
Sevin® (carbaryl)	35
S-lica	79
Silicates	78
Sodium bisulfate	132
Sodium carbonate	132
Sodium lauryl glyceryl ether sulfonate	129
Sodium dodecyl benzene sulfonate (Alkyl aryl sodium sulfonate)	128
Sodium hydroxide (Lye)	125
Sodium hypochlorite (Bleach)	126
Sodium metasilicate	132
Sodium tripolyphosphate	131
Stirofos	33
Stoddard Solvent (Mineral spirits)	85
Styrene	77
Sulfuric acid	170
Talc (Silicate)	78
Tetrachloroethylene (Perchloroethylene)	94
Tetraethyl lead	166
Tetramethrin (Pyrethrin)	136
Titanium dioxide	82
Toluene	86
1,1,1 Trichlorethane (Methyl chloroform)	95
Trichlorofon	34
Trichlorotrifluoroethane (Freon 113)	136
Tricresyl phosphate	167
Triethylene glycol	124
Trisodium phosphate	131
Turpentine	96
Urethane alkyds	76
Vapona® (Dichlorvos)	31
Vinyl acetate (Polyvinyl acetate)	74
VM + P Naphtha (Petroleum Spirits)	86
Warfarin (D-Con®)	47
Weed-B-Gon^R (2,4-D)	40

Chemical Name	Page
Xylene	87
Zinc naphthenate	100
Zinc Oxide	82